Google Earth Engine

Hands on Experience

Project 7 Fire and Hotspots

Introduction

Fire and Haze in Insular Southeast Asia

Vegetation fires, caused by various human activities, are a yearly occurrence on the island of Sumatra in Indonesia.

High resolution satellites can be used to detect these fires, because the resulting smoke plumes can be seen on the satellite images when they are not obscured by clouds. This imagery is also useful for analyzing land cover, and thus may be used to investigate the land cover changes associated with burning. E.g. Plantations can be identified by their regular grid-like pattern, and newly burnt areas are visible as dark patches of unvegetated land, called burn scars.

Another method of satellite fire detection is by using sensors in the thermal infrared region of the electromagnetic spectrum. The thermal infrared measurements can be used to estimate the temperature on the ground, and thus areas where the estimated temperature is unusually high can be flagged as suspected fires, or ‘hotspots’.

In this project, we will use imagery and hotspot data from the NASA Terra and Aqua satellites, captured with the 36-band MODIS sensor. We will also use higher resolution data from the European Space Agency’s Sentinel-2 optical satellites. These datasets can be displayed and analyzed in the Google Earth Engine.

MOD09/MYD09 MODIS Surface Reflectance Daily product

The MODIS Surface Reflectance products provide an estimate of the surface spectral reflectance as it would be measured at ground level in the absence of atmospheric scattering or absorption. Low-level data are corrected for atmospheric gases and aerosols. MOD09GA/MYD09GA version 6.1 provides bands 1-7 in a daily gridded L2G product in the sinusoidal projection, including 500m reflectance values and 1km observation and geolocation statistics.

FIRMS: Fire Information for Resource Management System

The GEE version of the Fire Information for Resource Management System (FIRMS) dataset contains the LANCE fire detection product in rasterized form. The near real-time (NRT) active fire locations are processed by LANCE using the standard MODIS MOD14/MYD14 Fire and Thermal Anomalies product. Each active fire location represents the centroid of a 1km pixel that is flagged by the algorithm as containing one or more fires within the pixel. For each FIRMS active fire point, a 1km bounding box (BB) is defined; pixels in the MODIS sinusoidal projection that intersect the FIRMS BB are identified; if multiple FIRMS BBs intersect the same pixel, the one with higher confidence is retained; in case of a tie, the brighter one is retained.

Sentinel-2 MSI: MultiSpectral Instrument, Level-1C

Sentinel-2 is a wide-swath, high-resolution, multi-spectral imaging mission supporting Copernicus Land Monitoring studies, including the monitoring of vegetation, soil and water cover, as well as observation of inland waterways and coastal areas. The Level-1C data contain 13 spectral bands representing top of atmosphere reflectance scaled by 10000.

Guided Lab

1. Hotspots

```
// Set the timeframe

// We want to look at data from the whole month of Sep 2023.
var from_date = '2023-09-01';
var upto_date = '2023-10-01';


// Load the FIRMS near-real-time MODIS detected active fire (or hotspot) dataset.
// We are only using the "Confidence" band in this dataset.

var dataset = ee.ImageCollection('FIRMS').filter(
    ee.Filter.date(from_date, upto_date));

// We select the max confidence values (0-100%) in each pixel and
// scale it to values from 0 to 1.
var fires = dataset.select('confidence').max().divide(100);

// Now let's look at only the pixels where
// the probability of fire is > 0.9 (or confidence > 90%).
// To do this, we use a mask; any pixels which do not satisfy the condition are masked out.
var hsmask = fires.gte(0.9);
var hotspots = fires.mask(hsmask);

// Let's centre the map in our region
Map.setCenter(107, 0.7, 6)

// Display those pixels which satisfy the above condition in red colour.
Map.addLayer(hotspots, {palette: ['red']}, 'Hotspots');

// Look closer at the island of Sumatra, in which province are most of the
// hotspots clustered in during the month of September?

// Count the total number of hotspots in an area of interest (AOI)
// Set a simple polygon covering Sumatra to be the AOI.
var aoi = ee.Geometry.Polygon(
    [[[93.661, 4.92],[103.58, -7.66],[109.26, -3.25],[95.46, 6.78]]]);

// The last part of the code sums up the total number of hotspots in the AOI
// and prints it out in the Code Editor Console.
var stats = hotspots.rename('hotspots').reduceRegion({
    reducer: ee.Reducer.sum(),
    geometry: aoi,
    scale: 1000,
});
print("Total number of hotspots in Sumatra = “,
      stats.getNumber('hotspots').round());
```

Guided Lab

2. Terra MODIS Imagery

```
// Now we will look at a MODIS image from which the hotspots are computed

// We have found that most hotspot activity in Sep 2023 in Sumatra was
// in the province of South Sumatra.
// So we shall set a rectangular AOI which covers South Sumatra.
// Let us take a look at the Terra MODIS image from Sep 28, which was
// relatively less cloudy compared to most other days in September.

var from_date = '2023-09-28';
var upto_date = '2023-09-29';

var AOI =  ee.Geometry.Rectangle(101.99, -1.54, 106.16, -5.04);


// Load the Terra MODIS surface reflectance dataset
var dataset = ee.ImageCollection('MODIS/061/MOD09GA')
                  .filter(ee.Filter.date(from_date, upto_date));

// There is only one image in the image collection for our timeframe,
// so we can just use the first() function to get the image from the collection.
var terra_image = dataset.first();

// There are 7 surface reflectance bands. These can be displayed in
// different band combinations.
// For this exercise, we will display in true colour (Red/Green/Blue)
// and NIR/Red/Green false colour.

var falseCol =
    terra_image.select(['sur_refl_b02', 'sur_refl_b01',
'sur_refl_b04']).clip(AOI);

// Whenever we display an image as a layer in the Code Editor map,
// we have to set the visualization parameters.
// For this exercise, suitable values have already been specified in the code.
// However, you can always modify the parameters of each layer
// by clicking on the gear icon.

var falseCol_vis = {
  min: 500.0,
  max: 4300.0,
};

Map.addLayer(falseCol, falseCol_vis, 'Terra MODIS False Colour 214');
```

Guided Lab

2. Terra MODIS Imagery (cont'd)

```
var truCol =
    terra_image.select(['sur_refl_b01', 'sur_refl_b04',
'sur_refl_b03']).clip(AOI);

var truCol_vis = {
  min: 0.0,
  max: 3500.0,
};

Map.addLayer(truCol, truCol_vis, 'Terra MODIS True Colour');


// Load the FIRMS dataset
var dataset = ee.ImageCollection('FIRMS')
    .filter(ee.Filter.date(from_date, upto_date))
    .filterBounds(AOI);
var fires = dataset.select('confidence').max().divide(100);
var hsmask = fires.gte(0.9);
var hotspots = fires.mask(hsmask);

// Overlay hotspots on the MODIS images
Map.addLayer(hotspots, {palette: ['red']}, 'Hotspots');

// Use the checkboxes in the Layers dropdown menu in the Code Editor map to
// toggle the layers on or off.
```

Guided Lab

3. Sentinel-2 Imagery

```
// Now let us have a close-up view of the smoke plumes.
// We will display a higher resolution Sentinel-2 image.
// One of the Sentinel-2 satellites had an overpass over the AOI on Sep 29,
// some smoke plumes can be seen on this image.

// Set the same timeframe and the area of interest (AOI)

var from_date = '2023-09-29';
var upto_date = '2023-09-30';

var AOI =  ee.Geometry.Rectangle(101.99, -1.54, 106.16, -5.04);


// Load the Sentinel-2 surface reflectance dataset
var dataset = ee.ImageCollection('COPERNICUS/S2_HARMONIZED')
                  .filter(ee.Filter.date(from_date, upto_date))
                  .filterBounds(AOI);

// Several Sentinel-2 tiles overlap our AOI, so we need to
// use the mosaic() function to combine them into one image
var S2_image = dataset.mosaic().divide(10000);

// There are 12 S2 reflectance bands. These can be displayed in different band
combinations.
// For this exercise, we will display in true colour (Red/Green/Blue)
// and two types of false colour: NIR/Red/Green and SWIR/NIR/Red.

var falseCol =
    S2_image.select(['B8', 'B4', 'B3']).clip(AOI);

// Whenever we display an image as a layer in the Code Editor map, we have to
// set the visualization parameters.
// For this exercise, suitable values have already been specified in the code.
// However, you can always modify the parameters of each layer by
// clicking on the gear icon.

var falseCol_vis = {
  min: 0.05,
  max: 0.4,
};

Map.addLayer(falseCol, falseCol_vis, 'Sentinel-2 False Colour 843');
```

Guided Lab

3. Sentinel-2 Imagery (cont'd)

```
var falseColSWIR =
    S2_image.select(['B12', 'B8', 'B4']).clip(AOI);

var falseColSWIR_vis = {
  min: 0.05,
  max: 0.7,
};

Map.addLayer(falseColSWIR, falseColSWIR_vis, 'Sentinel-2 False Colour 12/8/4');


var truCol =
    S2_image.select(['B4', 'B3', 'B2']).clip(AOI);

var truCol_vis = {
  min: 0.0,
  max: 0.3,
};

Map.addLayer(truCol, truCol_vis, 'Sentinel-2 True Colour 432');


// Load the FIRMS dataset
var dataset = ee.ImageCollection('FIRMS')
     .filter(ee.Filter.date(from_date, upto_date))
     .filterBounds(AOI);
var fires = dataset.select('confidence').max().divide(100);
var hsmask = fires.gte(0.9);
var hotspots = fires.mask(hsmask);

// Overlay hotspots on the MODIS images
Map.addLayer(hotspots, {palette: ['red']}, 'Hotspots');

// Use the checkboxes in the Layers dropdown menu in the Code Editor map to
// toggle the layers on or off.

// See if you can use all the layers to help find the smoke plumes in
// South Sumatra on this day.

// Compare and contrast the three S2 band combinations displayed here.

// Does the higher resolution of Sentinel-2 help identify the land features
// near the smoke plumes?
```

Further exploration

- What are the advantages and limitations of the satellite data used, and the methods of visualizing the data (e.g., different band combinations)?

- Track the development of the fire situation by recording a time-series of hotspot counts in a particular region.

- What methods are there to differentiate vegetation and non-vegetation?

- Clouds can be a problem for fire monitoring as they may be confused with smoke. Some clouds can be seen in the given satellite images; determine how clouds could be differentiated from smoke.

- Look for satellite images of fire in other time frames, and other locations in insular Southeast Asia.

- Do fires occur naturally in tropical rainforests?

- Which areas might be affected by smoke from fires in the AOI? What are the effects of the smoke?

- How useful is satellite imagery for detecting fire and monitoring land cover change? Are there any limitations to satellite data?