Google Earth Engine

Hands on Experience

Project 8 A view from above: Tracking Air Pollution and Volcanic Activity

Introduction

Volcanic Air Pollution and Health

Volcanoes are geographical formations where lava, small rocks, and steam are released onto the surface of the earth. There are hundreds of active volcanoes around the world. Inhaling volcanic gases and ash can be harmful to your health. Breathing in volcanic gases at high concentrations can cause mild symptoms, such as irritation of the eyes, and more severe symptoms, such as difficulty breathing or even death.

In this instructional guide, we shall provide a comprehensive overview of essential principles and applied methodologies for harnessing the extensive repository of satellite imagery, environmental datasets, and geospatial analysis utilities available through Google Earth Engine. We will specifically employ data products sourced from satellites to facilitate the quantification and visualization of volcanic eruption incidents and its impact on air pollution.

Mount Merapi, Indonesia's most active volcano. January 2021

Sentinel-5P TROPOspheric Monitoring Instrument (TROPOMI)

The assessment of volcanic activity may be facilitated through the examination of pertinent atmospheric constituents, notably Sulfur Dioxide (SO2). In the present instructional context, the TROPOMI instrumentation aboard the Sentinel-5P satellite stands as an instrumental asset, offering validated and high-resolution data concerning this particular pollutant. Its utilization serves as an illustrative methodology example employed in the monitoring of volcanic activities.

Sentinel-5P TROPOspheric Monitoring Instrument (TROPOMI)

S5P/TROPOMI samples the Earth's surface with a revisit time of one day with unprecedented spatial resolution of 3.5 x 7 km which allows the resolution of fine details including the detection of much smaller SO2 plumes.

Indonesia's Mount Merapi volcano erupts, tourism halts due to toxic gas and lava flows. March 2023

Guided Lab

1. Select the Dataset and date of interest

```
// Select dataset, variable name and target date
var setelah =
ee.ImageCollection('COPERNICUS/S5P/NRTI/L3_SO2').select('SO
2_column_number_density').filterDate('2020-08-11', '2020-
08-15');

// Define the threshold value for transparency
var threshold = 0.0005;

// Bar color and range
var band_viz = {
  min: 0.0002,
  max: 0.0015,
  opacity: 0.6,
  palette: ['#FFFFFF', '#0000FF', '#00FF00', '#FFFF00',
'#FF0000']
};
```

Guided Lab

2. Mask Data, centered map and add marker

```
// Mask values below the threshold
var setelahMasked =
setelah.mean().updateMask(setelah.mean().gte(threshold));
Map.addLayer(setelahMasked, band_viz);

// Select the center of your map
Map.setCenter(98.39, 3.17, 7);

// Add labels
var header = ui.Label('Map of SO2 Emission After M. Sinabung
Eruption', { fontSize: '25px', color: 'darkSlateGrey' });
var text_1 = ui.Label('Map of SO2 Emission around Mount Sinabung
captured by Sentinel-5P, August 2020', { fontSize: '15px' });
var toolPanel = ui.Panel([header, text_1], 'flow', { width:
'400px' });
ui.root.widgets().add(toolPanel);

// Add a marker to the volcanic activity site
// Define the specific latitude and longitude (lat-lon) for your
pin
var pinLat = 3.17;
var pinLon = 98.39;

// Create a pin marker using an ee.Geometry.Point
var pinMarker = ee.Geometry.Point([pinLon, pinLat]);

// Add the pin marker to the map as a black point
Map.addLayer(pinMarker, { color: 'black' },  'Pin Location');

// Create a label for the pin
var pinLabel = ui.Label('Mount Sinabung - Indonesia', { color:
'black' });

// Add the pin label to the map at the specified lat-lon
Map.add(ui.Panel([pinLabel], ui.Panel.Layout.flow('vertical')));
```

Guided Lab

2. Map Legend

```
// Color bar legend
var legendTitle2 = ui.Label({ value: 'S5P SO2 [mol/m^2]', style:
{ fontWeight: 'bold', fontSize: '15px', margin: '10px 0 0 0',
padding: '0' } });

// Panel configuration options
var legend = ui.Panel({ style: { position: 'bottom-right',
padding: '8px 15px' } });
var titleTextVis = { 'margin': '0px 0px 15px 0px', 'fontSize':
'18px', 'font-weight': '', 'color': '3333ff' };

// Create a legend title
var legendTitle = ui.Label('Legenda', titleTextVis);

// Added a second legend title
legend.add(legendTitle2);

// Create a legend image
var lon = ee.Image.pixelLonLat().select('latitude');
var gradient = lon.multiply((band_viz.max - band_viz.min) /
100.0).add(band_viz.min);
var legendImage = gradient.visualize(band_viz);

// Create text above the legend
var panel = ui.Panel({ widgets: [ui.Label('>
'.concat(band_viz['max']))], });
legend.add(panel);

// Displays the legend image
var thumbnail = ui.Thumbnail({ image: legendImage, params: {
bbox: '0,0,10,100', dimensions: '10x50' }, style: { padding:
'1px', position: 'bottom-center' } });

// Added an image to the legend
legend.add(thumbnail);

// Create text below the legend
var panel = ui.Panel({ widgets: [ui.Label(band_viz['min'])], });
legend.add(panel);

// Displays the legend on the main map
Map.add(legend);
```

Guided Lab

3. SO_2 monthly average comparison

```
// Replace the target date 11-14 August 2020 by 01-30
August 2019
var setelah =
ee.ImageCollection('COPERNICUS/S5P/NRTI/L3_SO2').select('SO
2_column_number_density').filterDate('2019-08-01', '2019-
08-30');
```

Question:
Compare the monthly average of the past year with the eruption period (11-15 August 2020) of the Mount Merapi volcano. Can you see the difference in SO2 concentrations?

Guided Lab

4. NO_2 monthly average comparison

```
// Replace the dataset/variable “COPERNICUS/S5P/NRTI/L3_SO2”/”
SO2_column_number_density” by “COPERNICUS/S5P/NRTI/L3_NO2”/”
NO2_column_number_density”

// Eruption period (11-14 August 2020)
var setelah =
ee.ImageCollection('COPERNICUS/S5P/NRTI/L3_NO2').select('NO2_co
lumn_number_density').filterDate('2020-08-11', '2020-08-14');


// Monthly average comparison (August 2019)
var setelah =
ee.ImageCollection('COPERNICUS/S5P/NRTI/L3_NO2').select('NO2_co
lumn_number_density').filterDate(‘2019-08-01', ‘2019-08-30');
```

Question:
Using the NO2 variable, compare the monthly average of the past year (2019) with the eruption period (11-15 August 2020) of the Mount Merapi volcano. Are you still able to visualize the impact of the eruption?

Guided Lab

5. Applying the concept to other volcanic eruptions around the world

Examples:

• Kīlauea Volcano eruption on December 20, 2020.
19.4069° N, 155.2834° W

• Cumbre Vieja volcanic eruption on September 19, 2021.
28.5728° N, 17.8375° W

Question:
Can you apply the analysis to other cases? Search the internet for eruptions that occurred in 2022 and try to show the impact on SO2 emissions and the size of the plume.
Hint: If necessary, change the minimum and maximum values.

Guided Lab

6. Applying split layout

```
// ################################################################
// Create the left map
var leftMap = ui.Map();
leftMap.setCenter(98.39, 3.17, 7);  // Set the center and zoom level for the left map

// Create the right map
var rightMap = ui.Map();
rightMap.setCenter(98.39, 3.17, 7);  // Set the center and zoom level for the right map

// Create a split panel to divide the maps
var splitPanel = ui.SplitPanel({
  firstPanel: leftMap,
  secondPanel: rightMap,
  orientation: 'horizontal', // 'vertical' can also be used for a vertical split
  style: { width: '100%' }
});

// Add the split panel to the user interface
ui.root.widgets().reset([splitPanel]);

// ################################################################
// Add layers to the left and right maps
var eruption =
ee.ImageCollection('COPERNICUS/S5P/NRTI/L3_SO2').select('SO2_column_number_density').filterDate('2
020-08-11', '2020-08-15');

// Define the threshold value for transparency
var threshold = 0.0004;

var band_viz = {
  min: 0.0002,
  max: 0.0015,
  opacity: 0.6,
  palette: ['#FFFFFF',  '#0000FF', '#00FF00', '#FFFF00',  '#FF0000']
};

// Mask values below the threshold
var eruptionMasked = eruption.mean().updateMask(eruption.mean().gte(threshold));

leftMap.addLayer(eruptionMasked, band_viz);
leftMap.setCenter(98.39, 3.17, 7);

var header = ui.Label('Map of SO2 Emission After M. Sinabung Eruption', { fontSize: '25px',
color: 'darkSlateGrey' });
var text_1 = ui.Label('Map of SO2 Emission around Mount Sinabung captured by Sentinel-5P, August
2020', { fontSize: '15px' });

var toolPanel = ui.Panel([header, text_1], 'flow', { width: '400px' });
ui.root.widgets().add(toolPanel);
```

Guided Lab

```
// Define the specific latitude and longitude (lat-lon) for your pin
var pinLat = 3.17;
var pinLon = 98.39;

// Create a pin marker using an ee.Geometry.Point
var pinMarker = ee.Geometry.Point([pinLon, pinLat]);

// Add the pin marker to the map
leftMap.addLayer(pinMarker, { color: 'black' },  'Pin Location');

// Create a label for the pin
var pinLabel = ui.Label('Mount Sinabung - Indonesia', { color: 'black' });

// Add the pin label to the map at the specified lat-lon
leftMap.add(ui.Panel([pinLabel], ui.Panel.Layout.flow('vertical')));

// Create a legend
var legendTitle2 = ui.Label({ value: 'S5P SO2 [mol/m^2]', style: { fontWeight: 'bold', fontSize: '15px', margin:
'10px 0 0 0', padding: '0' } });

// Create accessory panels and cartographic components
var legend = ui.Panel({ style: { position: 'bottom-right', padding: '8px 15px' } });
var titleTextVis  = { 'margin': '0px 0px 15px 0px', 'fontSize':  '18px', 'font-weight': '', 'color': '3333ff' };

// Create a legend title
var legendTitle = ui.Label('Legenda', titleTextVis);

// Added a second legend title
legend.add(legendTitle2);

// Create a legend image
var lon = ee.Image.pixelLonLat().select('latitude');
var gradient = lon.multiply((band_viz.max - band_viz.min) / 100.0).add(band_viz.min);
var legendImage = gradient.visualize(band_viz);

// Create text  above the legend
var panel = ui.Panel({ widgets: [ui.Label('> '.concat(band_viz['max']))], });
legend.add(panel);

// Displays the legend image
var thumbnail = ui.Thumbnail({ image: legendImage, params: { bbox:  '0,0,10,100', dimensions: '10x50' },
style: { padding: '1px', position: 'bottom-center' } });

// Added an image to the legend
legend.add(thumbnail);

// Create text  below the legend
var panel = ui.Panel({ widgets: [ui.Label(band_viz['min'])], });
legend.add(panel);

// Displays the legend on the main map
leftMap.add(legend);
```

Guided Lab

```
// ##############################################################
var eruption
= ee.ImageCollection('COPERNICUS/S5P/NRTI/L3_NO2').select('NO2_column_number_density').filterDate
('2020-08-11', '2020-08-15');

// Define the threshold value for transparency
var threshold = 0.00002;

var band_viz = {
  min: 0.00001,
  max: 0.0002,
  opacity: 0.5,
  //palette: ['white', 'purple', 'cyan', 'green', 'yellow', 'red'],
  palette: ['#FFFFFF', '#0000FF', '#00FF00', '#FFFF00', '#FF0000']
};

// Mask values below the threshold
var eruptionMasked = eruption.mean().updateMask(eruption.mean().gte(threshold));

rightMap.addLayer(eruptionMasked, band_viz);
rightMap.setCenter(98.39, 3.17, 7);

var header = ui.Label('Map of NO2 Emission After M. Sinabung Eruption', { fontSize: '25px',
color: 'darkSlateGrey' });
var text_1 = ui.Label('Map of NO2 Emission around Mount Sinabung captured by Sentinel-5P,
August 2020', { fontSize: '15px' });

var toolPanel = ui.Panel([header, text_1], 'flow', { width: '400px' });
ui.root.widgets().add(toolPanel);

// Define the specific latitude and longitude (lat-lon) for your pin
var pinLat = 3.17;
var pinLon = 98.39;

// Create a pin marker using an ee.Geometry.Point
var pinMarker = ee.Geometry.Point([pinLon, pinLat]);

// Add the pin marker to the map
rightMap.addLayer(pinMarker, { color: 'black' }, 'Pin Location');

// Create a label for the pin
var pinLabel = ui.Label('Mount Sinabung - Indonesia', { color: 'black' });

// Add the pin label to the map at the specified lat-lon
rightMap.add(ui.Panel([pinLabel], ui.Panel.Layout.flow('vertical')));

// Create a legend
var legendTitle2 = ui.Label({ value: 'S5P [NO2 mol/m^2]', style: { fontWeight: 'bold', fontSize: '15px',
margin: '10px 0 0 0', padding: '0' } });

// Create accessory panels and cartographic components
var legend = ui.Panel({ style: { position: 'bottom-right', padding: '8px 15px' } });
var titleTextVis = { 'margin': '0px 0px 15px 0px', 'fontSize': '18px', 'font-weight': '', 'color': '3333ff' };
```

Guided Lab

```
// Create a legend title
var legendTitle = ui.Label('Legenda', titleTextVis);

// Added a second legend title
legend.add(legendTitle2);

// Create a legend image
var lon = ee.Image.pixelLonLat().select('latitude');
var gradient = lon.multiply((band_viz.max - band_viz.min) / 100.0).add(band_viz.min);
var legendImage = gradient.visualize(band_viz);

// Create text  above the legend
var panel = ui.Panel({ widgets: [ui.Label('> '.concat(band_viz['max']))], });
legend.add(panel);

// Displays the legend image
var thumbnail = ui.Thumbnail({ image: legendImage, params: { bbox: '0,0,10,100', dimensions:
'10x50' }, style: { padding: '1px', position: 'bottom-center' } });

// Added an image to the legend
legend.add(thumbnail);

// Create text  below the legend
var panel = ui.Panel({ widgets: [ui.Label(band_viz['min'])], });
legend.add(panel);

// Displays the legend on the main map
rightMap.add(legend);
```