Google Earth Engine

Hands on Experience

Project 2 Wildfire monitoring using Sentinel-5P

Introduction

Wildfires

Wildfires are a natural part of many ecosystems, but their increasing frequency and intensity pose significant challenges to our environment and communities. With the power of Google Earth Engine, you can harness the capabilities of remote sensing and geospatial data to analyze, predict, and respond to wildfire events.

In this tutorial, we will take you through the fundamental concepts and practical techniques to leverage Google Earth Engine's vast collection of satellite imagery, environmental data, and geospatial analysis tools. Data products from Sentinel-5P will be used for the purpose of quantifying and visualizing wildfire events.

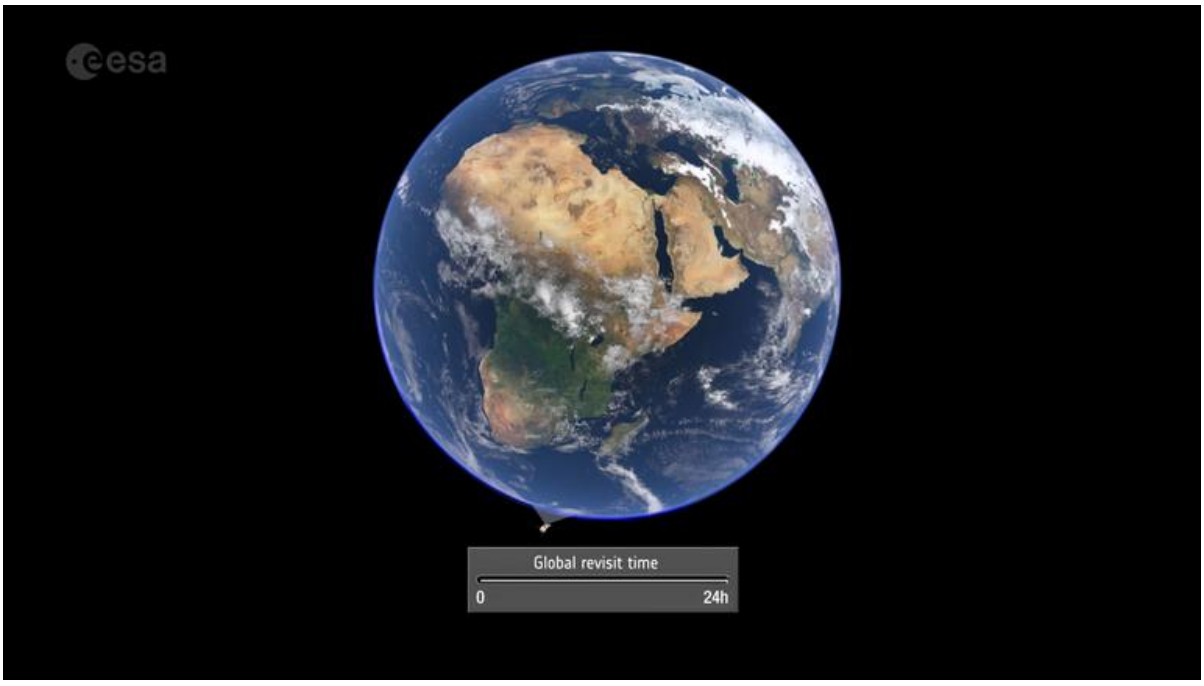
Wildfires in Attica, Greece. July 2023

Sentinel-5 Precursor

Wildfire monitoring can be done by investigating relevant atmospheric pollutants such as Nitrogen dioxide (NO_2), Carbon monoxide (CO) and aerosols such as PM2.5. The TROPOMI instrument onboard the Sentinel-5P satellite is capable of providing well-validated and high resolution data of these pollutants and will be used to demonstrate wildfire monitoring in this tutorial.

Sentinel-5P TROPOspheric Monitoring Instrument (TROPOMI)

- Spatial Resolution: 7x7 km^2
- Spectral range: ultraviolet and visible (270–495 nm), near infrared (675–775 nm) and shortwave infrared (2305–2385 nm)
- Swath width: 2600 km
- Temporal Resolution: Daily



Guided Lab

1. Set Area of Interest

```
//Our area of interest
var geometry =
    ee.Geometry.Point([23.475629, 38.062403]); //Attica
//    ee.Geometry.Point([28.021, 36.1635]); //Rhode Island

// Import a global dataset of administrative units level 1.
var adminUnits = ee.FeatureCollection(
    'FAO/GAUL_SIMPLIFIED_500m/2015/level1');

// Filter for the administrative unit that intersects
// the geometry located at the top of this script.
var adminSelect = adminUnits.filterBounds(geometry);

// Center the map on this area.
Map.centerObject(adminSelect, 7);

// Make the base map HYBRID.
Map.setOptions('HYBRID');

// Add it to the map to make sure you have what you want.
Map.addLayer(adminSelect, {}, 'selected admin unit');
```

Guided Lab

2. Data Selection & Preprocessing

```
// Import the Sentinel-5P NO2 offline product.
var no2Raw = ee.ImageCollection('COPERNICUS/S5P/OFFL/L3_NO2');
var coRaw = ee.ImageCollection('COPERNICUS/S5P/OFFL/L3_CO');
var AAIRaw = ee.ImageCollection('COPERNICUS/S5P/OFFL/L3_AER_AI');

// Define function to exclude cloudy pixels.
function maskClouds(image) {
    // Get the cloud fraction band of the image.
    var cf = image.select('cloud_fraction');
    // Create a mask using 0.3 threshold.
    var mask = cf.lte(0.3); // You can play around with this value.
    // Return a masked image.
    return image.updateMask(mask).copyProperties(image);
}

// Clean and filter the Sentinel-5P NO2 offline product.
var no2 = no2Raw
    // Filter for images intersecting our area of interest.
    .filterBounds(adminSelect)
    // Map the cloud masking function over the image collection.
    .map(maskClouds)
    // Select the tropospheric vertical column of NO2 band.
    .select('tropospheric_NO2_column_number_density');

// Clean and filter the Sentinel-5P CO offline product.
var co = coRaw
    // Filter for images intersecting our area of interest.
    .filterBounds(adminSelect)
    // Select the vertically integrated CO column density band.
    .select('CO_column_number_density');

// Clean and filter the Sentinel-5P UV Aerosol Index offline product.
var AAI = AAIRaw
    // Filter for images intersecting our area of interest.
    .filterBounds(adminSelect)
    // Select the absorbing aerosol index band.
    .select('absorbing_aerosol_index');
```

Question:

How are the data products (NO2, CO and AAI) used related to wildfire and air quality? What are the differences among them?

Guided Lab

2. Data Selection & Preprocessing

```
// Create a median composite for July 2022
var no2Median = no2.filterDate('2022-07-01', '2022-08-01').median();
var coMedian = co.filterDate('2022-07-01', '2022-08-01').median();
var AAIMedian = AAI.filterDate('2022-07-01', '2022-08-01').median();

// Clip it to your area of interest (only necessary for visualization purposes).
var no2MedianClipped = no2Median.clipToCollection(adminSelect);
var coMedianClipped = coMedian.clipToCollection(adminSelect);
var AAIMedianClipped = AAIMedian.clipToCollection(adminSelect);

// NO2 visualization options.
var no2Viz = {
    min: 0,
    max: 0.0002,
    palette: ['black', 'blue', 'purple', 'cyan', 'green',
        'yellow', 'red'
    ]
};
// CO visualization options.
var coViz = {
    min: 0,
    max: 0.05,
    palette: ['black', 'blue', 'purple', 'cyan', 'green',
        'yellow', 'red'
    ]
};
// AAI visualization options.
var AAIViz = {
    min: -1,
    max: 2,
    palette: ['black', 'blue', 'purple', 'cyan', 'green',
        'yellow', 'red'
    ]
};

Map.addLayer(no2MedianClipped, no2Viz, 'median no2 July 2022');
Map.addLayer(coMedianClipped, coViz, 'median co July 2022');
Map.addLayer(AAIMedianClipped, AAIViz, 'median AAI July 2022');
```

Question:

Can wildfire be identified using each of the remote sensing product?

Guided Lab

3. Quantifying and visualizing changes

```
// Define a wildfire NO2 median composite.
var no2fire = no2.filterDate('2023-07-17', '2023-07-20')
//var no2fire = no2.filterDate('2023-07-22', '2023-07-25')
    .median().clipToCollection(adminSelect);
//    .mean().clipToCollection(adminSelect);

// Define a wildfire CO median composite.
var cofire = co.filterDate('2023-07-17', '2023-07-20')
//var cofire = co.filterDate('2023-07-22', '2023-07-25')
    .median().clipToCollection(adminSelect);
//    .mean().clipToCollection(adminSelect);

// Define a wildfire AAI median composite.
var AAIfire = AAI.filterDate('2023-07-09', '2023-07-10')
//var AAIfire = AAI.filterDate('2023-07-22', '2023-07-25')
    .median().clipToCollection(adminSelect);
//    .mean().clipToCollection(adminSelect);

// Define a baseline NO2 using the month of July 2022.
var no2Baseline = no2.filterDate('2023-06-01', '2023-07-01')
    .median().clipToCollection(adminSelect);
//    .mean().clipToCollection(adminSelect);


// Define a baseline CO using the month of July 2022.
var coBaseline = co.filterDate('2023-06-01', '2023-07-01')
    .median().clipToCollection(adminSelect);
//    .mean().clipToCollection(adminSelect);


// Define a baseline AAI using the month of July 2022.
var AAIBaseline = AAI.filterDate('2022-07-01', '2022-08-01')
    .median().clipToCollection(adminSelect);
//    .mean().clipToCollection(adminSelect);

// Create a ui map widget to hold the baseline NO2 image.
var leftMap = ui.Map().centerObject(adminSelect, 7).setOptions(
    'HYBRID');

// Create ta ui map widget to hold the wildfire NO2 image.
var rightMap = ui.Map().setOptions('HYBRID');

// Create a split panel widget to hold the two maps.
var sliderPanel = ui.SplitPanel({
    firstPanel: leftMap,
    secondPanel: rightMap,
    orientation: 'horizontal',
    wipe: true,
    style: {
        stretch: 'both'
    }
});
```

Question:
Should we use median or mean for visualizing wildfire?

Guided Lab

3. Quantifying and visualizing changes

```
var linker = ui.Map.Linker([leftMap, rightMap]);

// Make a function to add a label.
function makeMapLab(lab, position) {
    var label = ui.Label({
        value: lab,
        style: {
            fontSize: '16px',
            color: '#ffffff',
            fontWeight: 'bold',
            backgroundColor: '#ffffff00',
            padding: '0px'
        }
    });
    var panel = ui.Panel({
        widgets: [label],
        layout: ui.Panel.Layout.flow('horizontal'),
        style: {
            position: position,
            backgroundColor: '#00000057',
            padding: '0px'
        }
    });
    return panel;
}

// Create baseline map layer, add it to the left map, and add the label.
var no2BaselineLayer = ui.Map.Layer(no2Baseline, no2Viz);
var coBaselineLayer = ui.Map.Layer(coBaseline, coViz);
var AAIBaselineLayer = ui.Map.Layer(AAIBaseline, AAIViz);

leftMap.layers().reset([no2BaselineLayer]);
//leftMap.layers().reset([coBaselineLayer]);
//leftMap.layers().reset([AAIBaselineLayer]);

leftMap.add(makeMapLab('Baseline 2022 July', 'top-left'));

// Create wildfire map layer, add it to the right map, and add the label.
var no2fireLayer = ui.Map.Layer(no2fire, no2Viz);
var cofireLayer = ui.Map.Layer(cofire, coViz);
var AAIfireLayer = ui.Map.Layer(AAIfire, AAIViz);

rightMap.layers().reset([no2fireLayer]);
//rightMap.layers().reset([cofireLayer]);
//rightMap.layers().reset([AAIfireLayer]);

rightMap.add(makeMapLab('Wildfire 2023 July', 'top-right'));

// Reset the map interface (ui.root) with the split panel widget.
// Note that the Map.addLayer() calls earlier on in Section 2
// will no longer be shown because we have replaced the Map widget
// with the sliderPanel widget.
ui.root.widgets().reset([sliderPanel]);
```

Question:
Compare the two maps in the split-panel map, do you find an increase in pollutants due to wildfire?

Guided Lab

3. Quantifying and visualizing changes

```
// Create a function to get the mean NO2 for the study region per image in the NO2
collection.
function getConc(collectionLabel, img) {
    return function(img) {
        // Calculate the mean NO2.
        var no2Mean = img.reduceRegion({
            reducer: ee.Reducer.mean(),
            geometry: adminSelect.geometry(),
            scale: 1000
        }).get('tropospheric_NO2_column_number_density');

        // Get the day-of-year of the image.
        var doy = img.date().getRelative('day', 'year');

        // Return a feature with NO2 concentration and day-of-year properties.
        return ee.Feature(null, {
            'conc': no2Mean,
            'DOY': doy,
            'type': collectionLabel
        });
    };
}
// Get the concentrations for a baseline and wildfire collection and merge for plotting.
var no2AggChange_forPlotting = no2
    .filterDate('2023-07-01', '2023-08-01')
    .map(getConc('wildfire'))
    .merge(no2.filterDate('2022-07-01', '2022-08-01')
        .map(getConc('baseline')));
no2AggChange_forPlotting = no2AggChange_forPlotting
    .filter(ee.Filter.notNull(['conc']));

// Make a chart.
var chart1 = ui.Chart.feature.groups(
        no2AggChange_forPlotting, 'DOY', 'conc', 'type')
    .setChartType('LineChart')
    .setOptions({
        title: 'DOY time series for mean [NO2] during ' +
            'July 2022 (baseline) and July 2023 (wildfire)'
    });

// Print it to the console.
print('Baseline vs wildfire NO2 for the study region by DOY', chart1);
```

Question:
Compare the time-series chart of all three pollutants, what are the differences?
Can you identify the wildfire from the time series chart? Why or why not?
Hint: Check satellite image over the AOI such as MODIS.