INSTITUTO FEDERAL DE EDUCAÇÃO, CIÊNCIA E TECNOLOGIA

GOIANO – CAMPUS CERES

PRÓ-REITORIA DE PESQUISA, PÓS-GRADUAÇÃO E INOVAÇÃO

PROGRAMA DE PÓS-GRADUAÇÃO EM IRRIGAÇÃO NO CERRADO

**SOFTWARE DE PROCESSAMENTO DIGITAL NA PLATAFORMA EM NUVEM DO GOOGLE EARTH ENGINE PARA DETERMINAÇÃO DE ÍNDICES DE VEGETAÇÃO NO VALE DO SÃO PATRÍCIO-GO COM BASE EM IMAGENS DO SATÉLITE LANDSAT-8 DA NASA**

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Esse script possui uma linguagem de programação computacional em Python dentro da plataforma Google Earth Engine (<https://earthengine.google.com/>), com dados de referência para o processamento de imagens orbitais do satélite Landsat-8 dos sensores Imageador Operacional Terrestre (Operational Land Imager – OLI) e Sensor Infravermelho Térmico (Thermal Infrared Sensor – TIRS). Com base nesse banco de dados geoespacial foi desenvolvido esse script/código visando o processamento digital de índices de vegetação, para monitorar a cobertura da terra de uma região no Estado de Goiás. Contudo, pode-se aplicar esse modelo em diferentes áreas de interesse, onde poderá caracterizar e visualizar as condições de mudanças por meio de mapas temáticos à superfície.

Baseou-se mais especificamente no produto da refletância da superfície e nas bandas multiespectrais do satélite Landsat, disponível na biblioteca do GEE com ID: ("LANDSAT/LC08/C02/T1\_L2"), que visa determinar o Índice de Vegetação da Diferença Normalizada (Normalized Difference Vegetation Index – NDVI) e Índice de Vegetação Ajustado ao Solo (Soil Adjusted Vegetation Index – SAVI), de 2013 a 2023, para o Vale do São Patrício, Goiás, Brasil.

Nota sobre o script a seguir: a partir do login/cadastro na plataforma Google Earth Engine, o usuário poderá acessar o código diretamente pelo link - (<https://code.earthengine.google.com/18eb1ff605a62d0b2727c8105bda0e76?noload=true>)

Todas as linhas do código acima também podem ser copiadas para o Google Earth Engine (GEE) a partir deste ponto a seguir, destacando que o GEE possui uma infraestrutura associada ao aprendizado de máquina:

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//-------------Land use and cover change patterns-------------//

//--------------------Vegetation Indices----------------------//

//------------Spatio-temporal analysis in 2013-2023-----------//

//------------Vale do São Patrício, Goiás - Brazil------------//

//---------LANDSAT-8, Operational Land Imager (OLI) sensor data------ --//

//--This dataset contains atmospherically corrected surface reflectance--//

 //----(NASA/LANDSAT-8 OLI - CHANDER et al., 2009)-----//

var SRTM = ee.Image('USGS/SRTMGL1\_003');

//Function to remove pixels without observation

var Pixelsvazios = function(image) {

//Finding pixels with observation

 var semObs = image.select('num\_observations\_30m').gt(0)

 return image.updateMask(semObs)

}

// This example demonstrates the use of the Landsat-8 Collection 2,

// Level 2 QA\_PIXEL band (CFMask) to mask unwanted pixels.

function maskL8sr(image) {

 // Bit 0 - Fill

 // Bit 1 - Dilated Cloud

 // Bit 2 - Unused

 // Bit 3 - Cloud

 // Bit 4 - Cloud Shadow

 var qaMask = image.select('QA\_RADSAT').bitwiseAnd(parseInt('11111', 2)).eq(0);

 var saturationMask = image.select('QA\_RADSAT').eq(0);

 // Apply the scaling factors to the appropriate bands.

 var opticalBands = image.select('SR\_B.').multiply(0.0000275).add(-0.2);

 var thermalBand = image.select('ST\_B.\*').multiply(0.00341802).add(149.0);

 // Replace the original bands with the scaled ones and apply the masks.

 return image.addBands(opticalBands, null, true)

 .addBands(thermalBand, null, true)

 .updateMask(qaMask)

 .updateMask(saturationMask);

}

// Map the function over one year of data.

var collection = ee.ImageCollection('LANDSAT/LC08/C02/T1\_L2')

 .filterDate('2013-03-18', '2023-12-31')

 .map(maskL8sr);

var composite = collection.median();

Map.addLayer(composite, {bands: ['SR\_B4', 'SR\_B3', 'SR\_B2'], min: 0, max: 0.3});

//Center on area

Map.centerObject(Land8, 10)

//Definition of the function of the physical-water parameters - OLI sensor

var parameters = function(image)

{

//-----------Vegetation Indices----------//

//Normalized Difference Vegetation Index - NDVI

var ndvi = image.expression(

 '(nir - red) / (nir + red)',

 {

 red: image.select('SR\_B4').multiply(0.0000275).add(-0.2), //636-673nm, RED

 nir: image.select('SR\_B5').multiply(0.0000275).add(-0.2) //851-879nm, NIR

 });

image = image.addBands(ndvi.rename('NDVI'));

//Soil Adjusted Vegetation Index - SAVI (L=0.40)

var savi = image.expression(

 '((1 + 0.40) \* (nir - red)) / (nir + red + 0.40)',

 {

 red: image.select('SR\_B4').multiply(0.0000275).add(-0.2), //636-673nm, RED

 nir: image.select('SR\_B5').multiply(0.0000275).add(-0.2) //851-879nm, NIR

 });

image = image.addBands(savi.rename('SAVI'));

return image;

};

//LANDSAT-8 Image Collection

var landparameters = ee.ImageCollection('LANDSAT/LC08/C02/T1\_L2')

 .filterDate('2013-03-18','2023-12-31')

 .map(parameters)

 .map(maskL8sr);

//Surface thematic map color palette - Viewing maps on the main screen

var palette\_ndvi = ['0d30af','2623fb','678dd4','39c4f9','a53310','f9d6aa','10931a','22761d']; //NDVI indice color palette

var palette\_savi =['0f680e','22b62d','1ef324','0717dc','f18c36','147e0d','36ba15','247a1e']; //SAVI water content color palette

/\*\*/

//Note: When clicking on any coordinate on the map, the graph values will highlight the pixel results.

//Chart of NDVI and SAVI

var panel = ui.Panel();

panel.style().set('width', '300px');

//Creating dashboard to observe the average data of the indices

var intro = ui.Panel([

 ui.Label({

 value: 'Two Chart Inspector',

 style: {fontSize: '20px', fontWeight: 'bold'},

}),

 ui.Label('Click a ponit on the map')

]);

panel.add(intro);

//Click on the canvas outside the map to load the graph and download general statistics

var lon = ui.Label();

var lat = ui.Label();

panel.add(ui.Panel((lon, lat), ui.Panel.Layout.flow('horizontal')));

Map.onClick(function(coords)

{

//Update panel from lon/lat

 lon.setValue('lon: ' + coords.lon.toFixed(2)),

 lat.setValue('lat: ' + coords.lat.toFixed(2));

//Add a red dot to the clicked point

 var point = ee.Geometry.Point(coords.lon, coords.lat);

 var dot = ui.Map.Layer(point, {color: 'FF0000'});

 Map.layers().set(1, dot);

 var chart = ui.Chart.image.series(landparameters.select('NDVI','SAVI'), point);

 chart.setOptions

 ({

 title: 'Índices de Vegetação ao longo do tempo',

 vAxis: {title: 'Valor Normalizado'},

 hAxis: {title: 'Data', format: 'MM-YY', gridlines: {count: 7}},

 });

 panel.widgets().set(2, chart);

//Add chart to map

chart.style().set

({

 position: 'bottom-right',

 width: '500px',

 height: '300px'

 });

Map.add(chart);

});

//Add panel

ui.root.insert(0, panel);

//Descriptive statistics of the parameters in the specified period (View console)

//Change the years in 'filterDate and select' - According to the same year in 'Export processed images'

var image2013 = landparameters

 .filterDate('2013-01-01','2013-12-31')

 .mean()

 .clip(Land8)

 .select('NDVI','SAVI');

var image2015 = landparameters

 .filterDate('2015-01-01','2015-12-31')

 .mean()

 .clip(Land8)

 .select('NDVI','SAVI');

var image2017 = landparameters

 .filterDate('2017-01-01','2017-12-31')

 .mean()

 .clip(Land8)

 .select('NDVI','SAVI');

var image2019 = landparameters

 .filterDate('2019-01-01','2019-12-31')

 .mean()

 .clip(Land8)

 .select('NDVI','SAVI');

var image2021 = landparameters

 .filterDate('2021-01-01','2021-12-31')

 .mean()

 .clip(Land8)

 .select('NDVI','SAVI');

var image2023 = landparameters

 .filterDate('2023-01-01','2023-12-31')

 .mean()

 .clip(Land8)

 .select('NDVI','SAVI');

//Digital processing of annual thematic maps of parameters, between 2013 and 2023

//Year 2013

var imagep2015 = landparameters

 .filterDate('2015-01-01','2015-12-31')

 .mean()

 .clip(Land8)

 .select('NDVI','SAVI');

//Year 2015

var imagep2015 = landparameters

 .filterDate('2015-01-01','2015-12-31')

 .mean()

 .clip(Land8)

 .select('NDVI','SAVI');

//Year 2017

var imagep2017 = landparameters

 .filterDate('2017-01-01','2017-12-31')

 .mean()

 .clip(Land8)

 .select('NDVI','SAVI');

//Year 2019

var imagep2019 = landparameters

 .filterDate('2019-01-01','2019-12-31')

 .mean()

 .clip(Land8)

 .select('NDVI','SAVI');

//Year 2021

var imagep2021 = landparameters

 .filterDate('2021-01-01','2021-12-31')

 .mean()

 .clip(Land8)

 .select('NDVI','SAVI');

//Year 2023

var imagep2023 = landparameters

 .filterDate('2023-01-01','2023-12-31')

 .mean()

 .clip(Land8)

 .select('NDVI','SAVI');

//Reduction of Collection 1 Region (Image1), according to the desired descriptive statistics

//Image 1 (2013)

var media2013 = image2013.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio2013 = image2013.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max2013 = image2013.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min2013 = image2013.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 2 (2015)

var media2015 = image2015.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio2015 = image2015.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max2015 = image2015.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min2015 = image2015.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 3 (2017)

var media2017 = image2017.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio2017 = image2017.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max2017 = image2017.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min2017 = image2017.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 4 (2019)

var media2019 = image2019.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio2019 = image2019.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max2019 = image2019.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min2019 = image2019.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 5 (2021)

var media2021 = image2021.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio2021 = image2021.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max2021 = image2021.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min2021 = image2021.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 6 (2023)

var media2023 = image2023.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio2023 = image2023.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max2023 = image2023.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min2023 = image2023.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land8.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Statistic result - Collection 1 - Print result (View in Console)

print(media2013,desvio2013,max2013,min2013); //Year 2013

print(media2015,desvio2015,max2015,min2015); //Year 2015

print(media2017,desvio2017,max2017,min2017); //Year 2017

print(media2019,desvio2019,max2019,min2019); //Year 2019

print(media2021,desvio2021,max2021,min2021); //Year 2021

print(media2023,desvio2023,max2023,min2023); //Year 2023

//Generation of thematic maps on the surface of collection 2

//2013

Map.addLayer(image2013,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_2013');

Map.addLayer(image2013,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_2013');

//2015

Map.addLayer(image2015,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_2015');

Map.addLayer(image2015,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_2015');

//2017

Map.addLayer(image2017,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_2017');

Map.addLayer(image2017,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_2017');

//2019

Map.addLayer(image2019,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_2019');

Map.addLayer(image2019,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_2019');

//2021

Map.addLayer(image2021,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_2021');

Map.addLayer(image2021,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_2021');

//2023

Map.addLayer(image2023,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_2023');

Map.addLayer(image2023,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_2023');

//Export processed images to Drive (annual physical-water parameters)

//Year-to-year printing

//Choose the time series year between 2013 and 2023 in 'description'

//2013

Export.image.toDrive({

 image: image2013.select('NDVI'),

 description: 'NDVI\_2013',

 region: Land8,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image2013.select('SAVI'),

 description: 'SAVI\_2013',

 region: Land8,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

//2015

Export.image.toDrive({

 image: image2015.select('NDVI'),

 description: 'NDVI\_2015',

 region: Land8,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image2015.select('SAVI'),

 description: 'SAVI\_2015',

 region: Land8,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

 //2017

 Export.image.toDrive({

 image: image2017.select('NDVI'),

 description: 'NDVI\_2017',

 region: Land8,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image2017.select('SAVI'),

 description: 'SAVI\_2017',

 region: Land8,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

 //2019

 Export.image.toDrive({

 image: image2019.select('NDVI'),

 description: 'NDVI\_2019',

 region: Land8,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image2019.select('SAVI'),

 description: 'SAVI\_2019',

 region: Land8,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

 //2021

 Export.image.toDrive({

 image: image2021.select('NDVI'),

 description: 'NDVI\_2021',

 region: Land8,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image2021.select('SAVI'),

 description: 'SAVI\_2021',

 region: Land8,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

 ///2023

Export.image.toDrive({

 image: image2023.select('NDVI'),

 description: 'NDVI\_2023',

 region: Land8,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image2023.select('SAVI'),

 description: 'SAVI\_2023',

 region: Land8,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });