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-5 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-5 do sensor Mapeador Temático (Thematic Mapper – TM). 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/LT05/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 1985 a 2011, 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/f7a26ca287506081cc4e67c39ee65e5e?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 1985-2011-----------//

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

//---------LANDSAT-5, Thematic Mapper (TM) sensor data--------//

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

 //----(NASA/LANDSAT-5 TM - 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 4, 5, 7 Collection 2,

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

function maskL457sr(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\_B6').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/LT05/C02/T1\_L2')

 .filterDate('1985-01-01', '2011-12-31')

 .map(maskL457sr);

var composite = collection.median();

Map.addLayer(composite, {bands: ['SR\_B3', 'SR\_B2', 'SR\_B1'], min: 0, max: 0.3});

//Center on area

Map.centerObject(Land5, 10)

//Definition of the function of the physical-water parameters - TM sensors

var parameters = function(image)

{

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

//Normalized Difference Vegetation Index - NDVI

var ndvi = image.expression(

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

 {

 red: image.select('SR\_B3').multiply(0.0000275).add(-0.2), //636-673nm, RED

 nir: image.select('SR\_B4').multiply(0.0000275).add(-0.2) //851-879nm, NIR

 });

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

//Soil Adjusted Vegetation Index - SAVI (L=0.40) //L - FATOR DE AJUSTE AO SOLO

var savi = image.expression(

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

 {

 red: image.select('SR\_B3').multiply(0.0000275).add(-0.2), //636-673nm, RED

 nir: image.select('SR\_B4').multiply(0.0000275).add(-0.2) //851-879nm, NIR

 });

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

return image;

};

//LANDSAT-5 Image Collection

var landparameters = ee.ImageCollection('LANDSAT/LT05/C02/T1\_L2')

 .filterDate('1985-01-01', '2011-12-31')

 .map(parameters)

 .map(maskL457sr);

//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: 'Vegetation Index over time',

 vAxis: {title: 'Normalized Value'},

 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 image1985 = landparameters

 .filterDate('1985-01-01','1985-12-31')

 .mean()

 .clip(Land5)

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

var image1987 = landparameters

 .filterDate('1987-01-01','1987-12-31')

 .mean()

 .clip(Land5)

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

var image1989 = landparameters

 .filterDate('1989-01-01','1989-12-31')

 .mean()

 .clip(Land5)

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

var image1991 = landparameters

 .filterDate('1991-01-01','1991-12-31')

 .mean()

 .clip(Land5)

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

var image1993 = landparameters

 .filterDate('1993-01-01','1993-12-31')

 .mean()

 .clip(Land5)

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

var image1995 = landparameters

 .filterDate('1995-01-01','1995-12-31')

 .mean()

 .clip(Land5)

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

var image1997 = landparameters

 .filterDate('1997-01-01','1997-12-31')

 .mean()

 .clip(Land5)

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

var image1999 = landparameters

 .filterDate('1999-01-01','1999-12-31')

 .mean()

 .clip(Land5)

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

var image2001 = landparameters

 .filterDate('2001-01-01','2001-12-31')

 .mean()

 .clip(Land5)

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

var image2003 = landparameters

 .filterDate('2003-01-01','2003-12-31')

 .mean()

 .clip(Land5)

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

var image2005 = landparameters

 .filterDate('2005-01-01','2005-12-31')

 .mean()

 .clip(Land5)

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

var image2007 = landparameters

 .filterDate('2007-01-01','2007-12-31')

 .mean()

 .clip(Land5)

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

var image2009 = landparameters

 .filterDate('2009-01-01','2009-12-31')

 .mean()

 .clip(Land5)

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

var image2011 = landparameters

 .filterDate('2011-01-01','2011-12-31')

 .mean()

 .clip(Land5)

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

//Digital processing of annual thematic maps of parameters, between 1985 and 2011

//Year 1985-2011

var imagep1985 = landparameters

 .filterDate('1985-01-01','1985-12-31')

 .mean()

 .clip(Land5)

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

var imagep1987 = landparameters

 .filterDate('1987-01-01','1987-12-31')

 .mean()

 .clip(Land5)

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

var imagep1989 = landparameters

 .filterDate('1989-01-01','1989-12-31')

 .mean()

 .clip(Land5)

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

var imagep1991 = landparameters

 .filterDate('1991-01-01','1991-12-31')

 .mean()

 .clip(Land5)

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

var imagep1993 = landparameters

 .filterDate('1993-01-01','1993-12-31')

 .mean()

 .clip(Land5)

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

var imagep1995 = landparameters

 .filterDate('1995-01-01','1995-12-31')

 .mean()

 .clip(Land5)

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

var imagep1997 = landparameters

 .filterDate('1997-01-01','1997-12-31')

 .mean()

 .clip(Land5)

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

var imagep1999 = landparameters

 .filterDate('1999-01-01','1999-12-31')

 .mean()

 .clip(Land5)

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

var imagep2001 = landparameters

 .filterDate('2001-01-01','2001-12-31')

 .mean()

 .clip(Land5)

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

var imagep2003 = landparameters

 .filterDate('2003-01-01','2003-12-31')

 .mean()

 .clip(Land5)

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

var imagep2005 = landparameters

 .filterDate('2005-01-01','2005-12-31')

 .mean()

 .clip(Land5)

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

var imagep2007 = landparameters

 .filterDate('2007-01-01','2007-12-31')

 .mean()

 .clip(Land5)

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

var imagep2009 = landparameters

 .filterDate('2009-01-01','2009-12-31')

 .mean()

 .clip(Land5)

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

var imagep2011 = landparameters

 .filterDate('2011-01-01','2011-12-31')

 .mean()

 .clip(Land5)

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

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

//Image 1 (1985)

var media1985 = image1985.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio1985 = image1985.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max1985 = image1985.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min1985 = image1985.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 2 (1987)

var media1987 = image1987.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio1987 = image1987.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max1987 = image1987.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min1987 = image1987.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 3 (1989)

var media1989 = image1989.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio1989 = image1989.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max1989 = image1989.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min1989 = image1989.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 4 (1991)

var media1991 = image1991.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio1991 = image1991.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max1991 = image1991.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min1991 = image1991.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 5 (1993)

var media1993 = image1993.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio1993 = image1993.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max1993 = image1993.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min1993 = image1993.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 6 (1995)

var media1995 = image1995.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio1995 = image1995.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max1995 = image1995.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min1995 = image1995.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 7 (1997)

var media1997 = image1997.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio1997 = image1997.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max1997 = image1997.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min1997 = image1997.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 8 (1999)

var media1999 = image1999.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio1999 = image1999.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max1999 = image1999.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min1999 = image1999.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 9 (2001)

var media2001 = image2001.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio2001 = image2001.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max2001 = image2001.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min2001 = image2001.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 10 (2003)

var media2003 = image2003.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio2003 = image2003.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max2003 = image2003.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min2003 = image2003.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 11 (2005)

var media2005 = image2005.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio2005 = image2005.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max2005 = image2005.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min2005 = image2005.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 12 (2007)

var media2007 = image2007.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio2007 = image2007.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max2007 = image2007.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min2007 = image2007.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 13 (2009)

var media2009 = image2009.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio2009 = image2009.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max2009 = image2009.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min2009 = image2009.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

//Image 14 (2011)

var media2011 = image2011.reduceRegion({

 reducer: ee.Reducer.mean(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var desvio2011 = image2011.reduceRegion({

 reducer: ee.Reducer.stdDev(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var max2011 = image2011.reduceRegion({

 reducer: ee.Reducer.max(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

var min2011 = image2011.reduceRegion({

 reducer: ee.Reducer.min(),

 geometry: Land5.geometry(),

 scale: 30,

 maxPixels: 1e13

});

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

print(media1985,desvio1985,max1985,min1985); //Year 1985

print(media1987,desvio1987,max1987,min1987); //Year 1987

print(media1989,desvio1989,max1989,min1989); //Year 1989

print(media1991,desvio1991,max1991,min1991); //Year 1991

print(media1993,desvio1993,max1993,min1993); //Year 1993

print(media1995,desvio1995,max1995,min1995); //Year 1995

print(media1997,desvio1997,max1997,min1997); //Year 1997

print(media1999,desvio1999,max1999,min1999); //Year 1999

print(media2001,desvio2001,max2001,min2001); //Year 2001

print(media2003,desvio2003,max2003,min2003); //Year 2003

print(media2005,desvio2005,max2005,min2005); //Year 2005

print(media2007,desvio2007,max2007,min2007); //Year 2007

print(media2009,desvio2009,max2009,min2009); //Year 2009

print(media2011,desvio2011,max2011,min2011); //Year 2011

//Generation of thematic maps on the surface of collection 1

//1985

Map.addLayer(image1985,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_1985');

Map.addLayer(image1985,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_1985');

//1987

Map.addLayer(image1987,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_1987');

Map.addLayer(image1987,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_1987');

//1989

Map.addLayer(image1989,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_1989');

Map.addLayer(image1989,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_1989');

//1991

Map.addLayer(image1991,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_1991');

Map.addLayer(image1991,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_1991');

//1993

Map.addLayer(image1993,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_1993');

Map.addLayer(image1993,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_1993');

//1995

Map.addLayer(image1995,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_1995');

Map.addLayer(image1995,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_1995');

//1997

Map.addLayer(image1997,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_1997');

Map.addLayer(image1997,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_1997');

//1999

Map.addLayer(image1999,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_1999');

Map.addLayer(image1999,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_1999');

//2001

Map.addLayer(image2001,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_2001');

Map.addLayer(image2001,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_2001');

//2003

Map.addLayer(image2003,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_2003');

Map.addLayer(image2003,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_2003');

//2005

Map.addLayer(image2005,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_2005');

Map.addLayer(image2005,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_2005');

//2007

Map.addLayer(image2007,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_2007');

Map.addLayer(image2007,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_2007');

//2009

Map.addLayer(image2009,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_2009');

Map.addLayer(image2009,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_2009');

//2011

Map.addLayer(image2011,{min: -1, max: 1,bands:['NDVI'], palette: palette\_ndvi},'NDVI\_2011');

Map.addLayer(image2011,{min: -1, max: 1,bands:['SAVI'], palette: palette\_savi},'SAVI\_2011');

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

//Year-to-year printing

//Choose the time series year between 1985 and 2011 in 'description'

//1985

Export.image.toDrive({

 image: image1985.select('NDVI'),

 description: 'NDVI\_1985',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image1985.select('SAVI'),

 description: 'SAVI\_1985',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

//1987

Export.image.toDrive({

 image: image1987.select('NDVI'),

 description: 'NDVI\_1987',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image1987.select('SAVI'),

 description: 'SAVI\_1987',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

 //1989

 Export.image.toDrive({

 image: image1989.select('NDVI'),

 description: 'NDVI\_1989',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image1989.select('SAVI'),

 description: 'SAVI\_1989',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

 //1991

Export.image.toDrive({

 image: image1991.select('NDVI'),

 description: 'NDVI\_1991',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image1991.select('SAVI'),

 description: 'SAVI\_1991',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

 //1993

Export.image.toDrive({

 image: image1993.select('NDVI'),

 description: 'NDVI\_1993',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image1993.select('SAVI'),

 description: 'SAVI\_1993',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

//1995

 Export.image.toDrive({

 image: image1995.select('NDVI'),

 description: 'NDVI\_1995',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image1995.select('SAVI'),

 description: 'SAVI\_1995',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

 //1997

 Export.image.toDrive({

 image: image1997.select('NDVI'),

 description: 'NDVI\_1997',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image1997.select('SAVI'),

 description: 'SAVI\_1997',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

//1999

Export.image.toDrive({

 image: image1999.select('NDVI'),

 description: 'NDVI\_1999',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image1999.select('SAVI'),

 description: 'SAVI\_1999',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

//2001

 Export.image.toDrive({

 image: image2001.select('NDVI'),

 description: 'NDVI\_2001',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image2001.select('SAVI'),

 description: 'SAVI\_2001',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

//2003

Export.image.toDrive({

 image: image2003.select('NDVI'),

 description: 'NDVI\_2003',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image2003.select('SAVI'),

 description: 'SAVI\_2003',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

//2005

Export.image.toDrive({

 image: image2005.select('NDVI'),

 description: 'NDVI\_2005',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image2005.select('SAVI'),

 description: 'SAVI\_2005',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

 //2007

Export.image.toDrive({

 image: image2007.select('NDVI'),

 description: 'NDVI\_2007',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image2007.select('SAVI'),

 description: 'SAVI\_2007',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

//2009

 Export.image.toDrive({

 image: image2009.select('NDVI'),

 description: 'NDVI\_2009',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

Export.image.toDrive({

 image: image2009.select('SAVI'),

 description: 'SAVI\_2009',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });

 //2011

Export.image.toDrive({

 image: image2011.select('NDVI'),

 description: 'NDVI\_2011',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_NDVI\_São\_Patrício'

 });

 Export.image.toDrive({

 image: image2011.select('SAVI'),

 description: 'SAVI\_2011',

 region: Land5,

 scale: 30,

 crs: 'EPSG: 4326',

 fileFormat: 'GeoTIFF',

 folder: 'Land\_SAVI\_São\_Patrício'

 });