ANALYSIS OF URBAN SPRAWL IN GUANGDONG PROVINCE, CHINA

CPLN 670 Geospatial software design

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Introduction

- Chinese cities have undergone increasing urbanization that has resulted in significant urban sprawl in the recent 20 years. According to the literature review, unlike western countries, in which urban sprawl always means excessive suburbanization, now China is experiencing a high speed of urbanization, but the process of suburbanization does not occur until now. In other words, urban sprawl in China is a low-density urbanization, rather than excessive suburbanization like western countries, which should be emphasized in this project. However, there are still some similar characteristics and confluences of urban sprawl both in China and western countries. Just like urban sprawl in cities of U.S., the impervious area of cities grows much faster than the population.
- This project is going to analyze the characteristics and patterns of urban sprawl in Guangdong province, China. The change of urban built-up area, vegetation(NDVI), population density, and heat island effect, which are associated with urban sprawl phenomenon, are examined in the project.

Study area

The project selects Guangdong province, one of most highly urbanized areas of China, as the study area to study its urban sprawl in the past 20 years. In addition to the overall patterns, four cities will be analyzed, including two major cities—Guangzhou(the capital of Guangdong province), Shenzhen, city adjacent to Guangzhou city—Zhongshan, a prefecture-level city(far away from Guangzhou)—Shaoguan.

Methodology

To analyze the urban sprawl phenomenon, one important step is to identify the extent of urban built-up area. Night light data is going to be used here to extract the urban built-up area. To understand the characteristics and patterns of urban sprawl, the change of vegetation, population density, and heat island effect will be analyzed. In this part, I will use Linear Regression to analyze multi-temporal data and understand the trends of each factor.

Data sources

1.China Administrative Boundary: Retrieved from GADM database of Global Administrative Areas

2.DMSP OLS: Nighttime Lights Time Series Version 4

3. MCD12Q1.051 Land Cover Type Yearly Global 500m (MODIS/051/MCD12Q1)

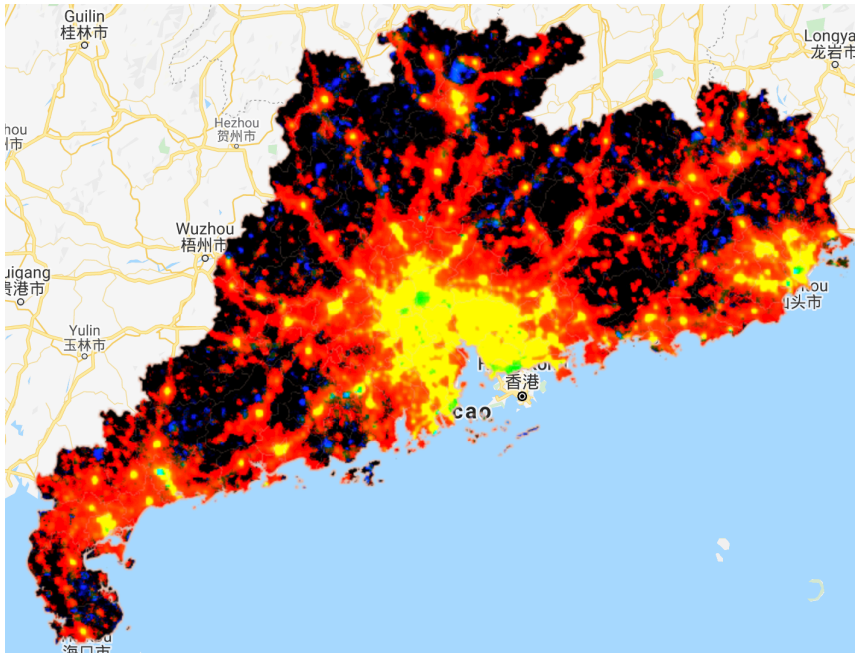
4.WorldPop Global Project Population Data: Estimated Residential Population per 100x100m Grid Square

5.MOD13A1.006 Terra Vegetation Indices 16-Day Global 500m

6. MOD11A1.006 Terra Land Surface Temperature and Emissivity Daily Global 1km

Night light analysis

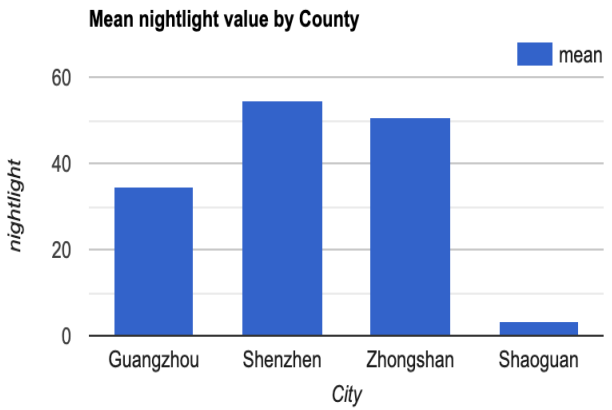
```
/*PART1 NIGHT LIGHT*/
function createTimeBand(img) {
  var year = ee.Date(img.get('system:time_start')).get('year').subtract(2000);
  return ee.Image(year).byte().addBands(img);
}

// Map the time band creation helper over the night-time lights collection.
var collection = ee.ImageCollection('NOAA/DMSP-OLS/NIGHTTIME_LIGHTS')
    .select('stable_lights')
    .map(createTimeBand);

var trend = collection.reduce(ee.Reducer.linearFit());
var trendClipped = trend.clip(Guangdong);

// Compute a linear fit over the series of values at each pixel, visualizing
// the y-intercept in green, and positive/negative slopes as red/blue.
Map.centerObject(Guangdong);
Map.addLayer(trendClipped, {min: 0, max: [0.18, 30, -0.18], bands: ['scale', 'offset', 'scale']}, 'stable lights trend');
```

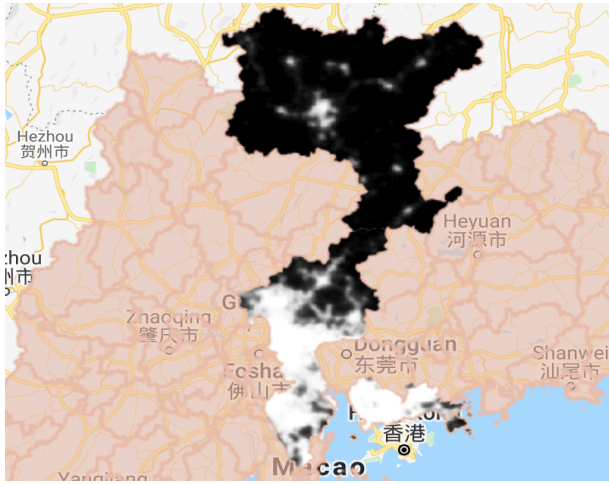


The nightlight of the center of the two big cities Guangzhou and Shenzhen remain stable in these years. Areas adjcent to the two cities have increasing bright urban areas in the past 20 years, while there is a decreasing trend in some areas that are far away from the major cities.

Night light analysis (four cities)

```
//extract the four cities
var addname_gz = function(feature) {return feature.set({name: 'Guangzhou'});};
var addname_sz = function(feature) {return feature.set({name: 'Shenzhen'});};
var addname_zs = function(feature) {return feature.set({name: 'Zhongshan'});};
var addname_sg = function(feature) {return feature.set({name: 'Shaoguan'});};
var gz = Guangdong.filterMetadata('NAME_2','equals',('Guangzhou')).union().set('name', 'Guangzhou')
var gz_union = gz.map(addname_gz);
var sz = Guangdong.filterMetadata('NAME_2','equals',('Shenzhen')).union().set('name', 'Shenzhen')
var sz_union = sz.map(addname_sz);
var zs = Guangdong.filterMetadata('NAME_2','equals',('Zhongshan')).union().set('name', 'Zhongshan')
var zs_union = zs.map(addname_zs);
var sg = Guangdong.filterMetadata('NAME_2','equals',('Shaoguan')).union().set('name', 'Shaoguan')
var sg_union = sg.map(addname_sg);
var all = gz_union.merge(sz_union).merge(zs_union).merge(sg_union);
var light13 = ee.Image('NOAA/DMSP-OLS/NIGHTTIME_LIGHTS/F182013').select('stable_lights').clip(all);
var nighttimeLightsVis = {min: 3.0,max: 60.0,};
Map.addLayer(light13,nighttimeLightsVis,'2013 Lights');
var TheCHART4 = ui.Chart.image.byRegion(light13,all,ee.Reducer.mean(),300,'name');
var TheCHART4 = TheCHART4.setChartType('ColumnChart').setOptions({title:'Mean nightlight value by County',
hAxis:{title:'City'},vAxis:{ title: 'nightlight'} });
print(TheCHART4);
```

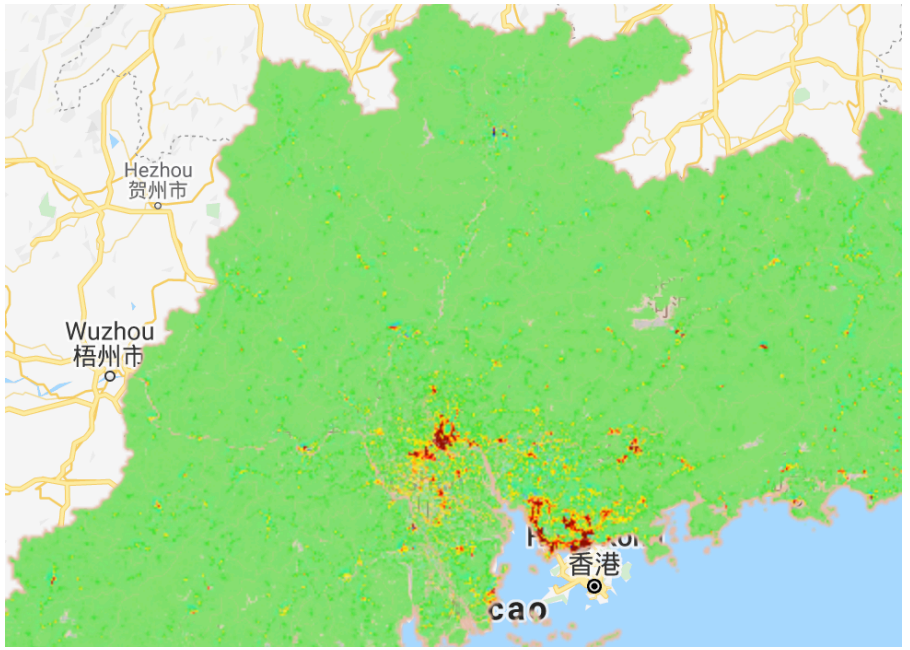




In 2013, Shenzhen is the city with the brightest nightlight. Since Guangzhou includes lots of suburban areas, its mean value of the night light is lower than Zhongshan. Together with the chart of the former page (showing an increasing trend in this city), we can know that Zhongshan experienced significant urban growth.

Population

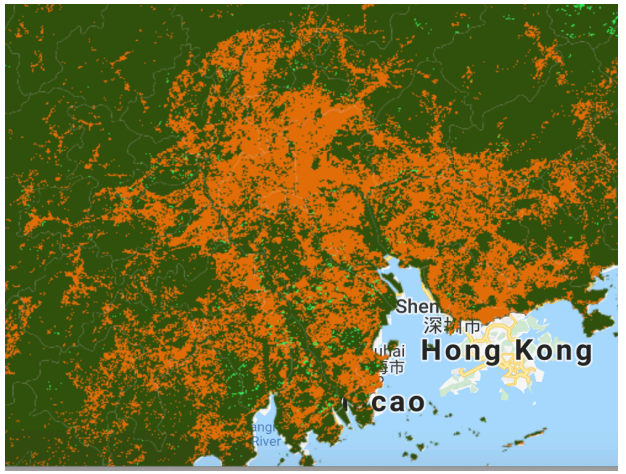
```
var year_list=ee.List.sequence(2000,2019);
year_list=year_list.map(function(num){
  var time=ee.Date.fromYMD(num, 1, 1)
  var year_image=ee.ImageCollection('WorldPop/GP/100m/pop')
                .filterDate(time,ee.Date(time).advance(1,'year')).max();
  var year_ndvi=year_image.select('population');
  return  year_ndvi.addBands(ee.Image.constant(num).toFloat());   } )
var img_collection=ee.ImageCollection.fromImages(year_list);
var linearFit = img_collection.select(['constant', 'population']).reduce(ee.Reducer.linearFit());

var trendVis = {
  min: -6, max: 6,
  palette: [
    '040274', '040281', '0502a3', '0502b8', '0502ce', '0502e6',
    '0602ff', '235cb1', '307ef3', '269db1', '30c8e2', '32d3ef',
    '3be285', '3ff38f', '86e26f', '3ae237', 'b5e22e', 'd6e21f',
    'fff705', 'ffd611', 'ffb613', 'ff8b13', 'ff6e08', 'ff500d',
    'ff0000', 'de0101', 'c21301', 'a71001', '911003'] };
Map.addLayer(linearFit.select('scale').clip(Guangdong),trendVis,'population trend');
```



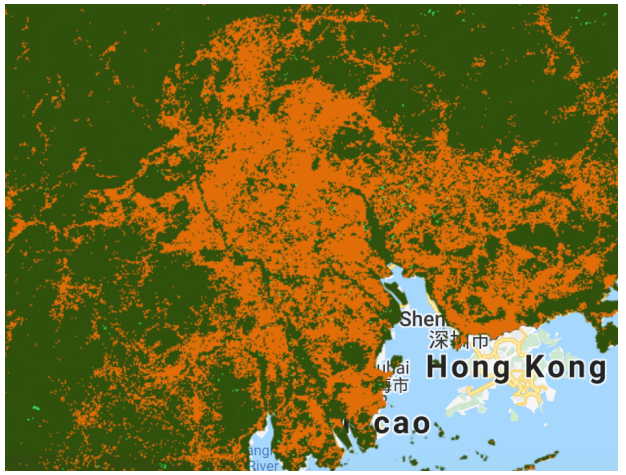
Except for the two major cities Guangzhou and Shenzhen, which experience population growth, other areas' populations remain stable.

Landcover

```
var landuse2010_original = ee.Image('MODIS/051/MCD12Q1/2013_01_01').select('Land_Cover_Type_1');
var landuse2001_original = ee.Image('MODIS/051/MCD12Q1/2001_01_01').select('Land_Cover_Type_1')
var landuse2010_clip = landuse2010_original.clip(Guangdong);
var landuse2001_clip = landuse2001_original.clip(Guangdong);

var ColorsForMODIS = [...].join(',');   (see the code afterwards)

var landuse2010 = landuse2010_clip.remap( [0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17],
[1,4,1,1,1,1,1,1,1,1,1,2,2,1,1,1,4], 0, 'Land_Cover_Type_1');
var landuse2001 = landuse2001_clip.remap( [0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17],
[1,4,1,1,1,1,1,1,1,1,1,2,2,1,1,1,4], 0, 'Land_Cover_Type_1');

Map.addLayer(landuse2001,{ min:0, max:17, palette:ColorsForMODIS },'LU2001');
Map.addLayer(landuse2010,{ min:0, max:17, palette:ColorsForMODIS },'LU2010');

// Identify land use changes between 2001 and 2010
var type_change = landuse2010.subtract(landuse2001);
var type_change_abs = type_change.abs();

// Land use changing from the natural to the urban(cropland);
var UrbantoNature = type_change.remap([0,1,2,3,-1,-2,-3],[0,0,0,0,1,0,0],0);
Map.addLayer (UrbantoNature, {opacity:0.7}, 'Urban to Nature' );
```



2001

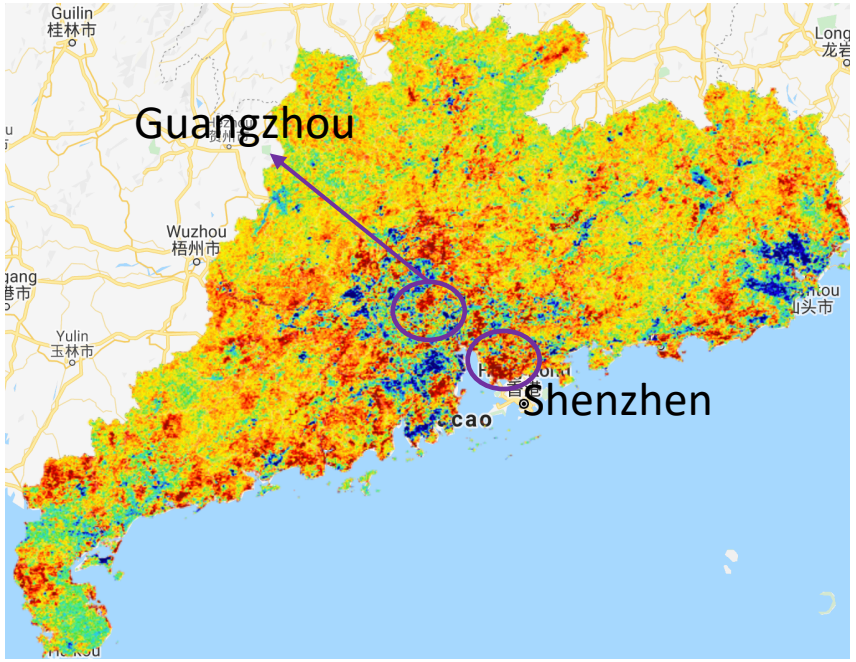


2010

More land change from the natural type to the urban/cropland type in the 10 years.

Vegetation

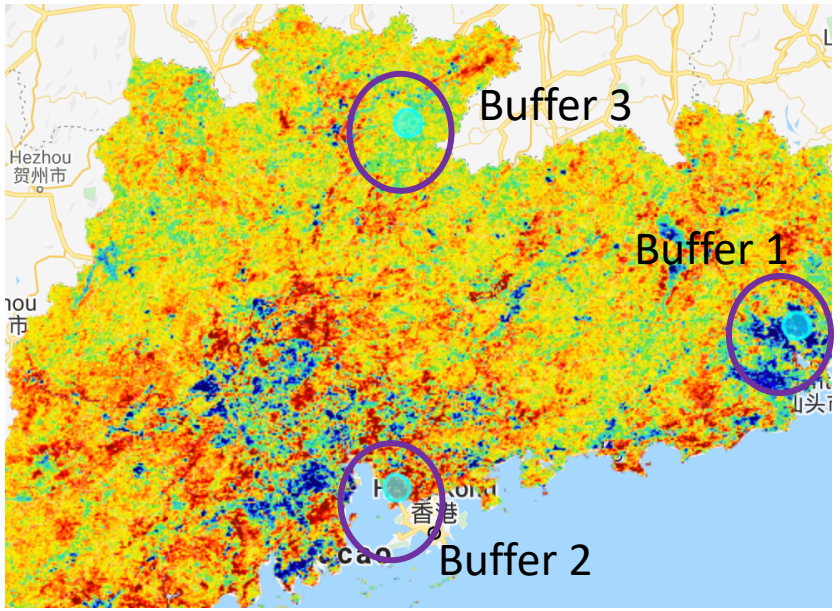
```
// Maximum Value Composite of NDVI
var year_list=ee.List.sequence(2000,2019);
year_list=year_list.map(function(num){
  var time=ee.Date.fromYMD(num, 1, 1)
  var year_image=ee.ImageCollection('MODIS/006/MOD13A1')
                .filterDate(time,ee.Date(time).advance(1,'year'))
                .max();
  var year_ndvi=year_image.select('NDVI');
  return  year_ndvi.addBands(ee.Image.constant(num).toFloat());   })
var img_collection=ee.ImageCollection.fromImages(year_list);
var linearFit = img_collection.select(['constant', 'NDVI']).reduce(ee.Reducer.linearFit());
var trendVis = {
  min: -100, max: 100,
  palette: [
    '040274', '040281', '0502a3', '0502b8', '0502ce', '0502e6',
    '0602ff', '235cb1', '307ef3', '269db1', '30c8e2', '32d3ef',
    '3be285', '3ff38f', '86e26f', '3ae237', 'b5e22e', 'd6e21f',
    'fff705', 'ffd611', 'ffb613', 'ff8b13', 'ff6e08', 'ff500d',
    'ff0000', 'de0101', 'c21301', 'a71001', '911003'] };
Map.addLayer(linearFit.select('scale').clip(Guangdong),trendVis);
```

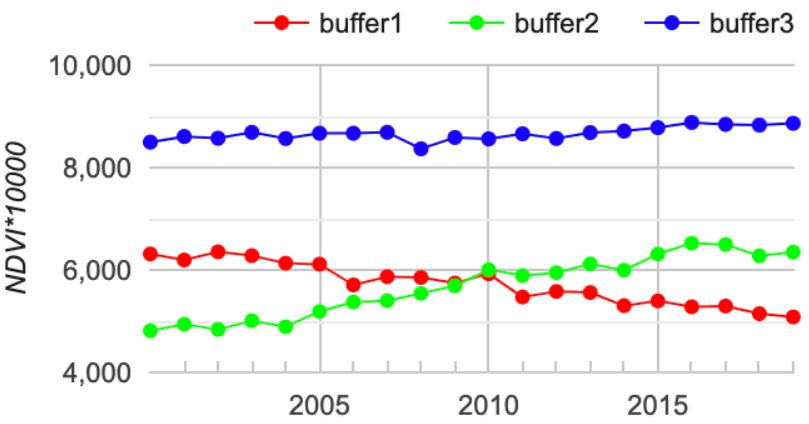


The red color represent an increase in NDVI and the blue color represent a decrease in NDVI. Therefore, Guangzhou and Shenzhen become greener in these few years, while the areas adjacent to the two major cities experience vegetation loss.

Vegetation (three regions)

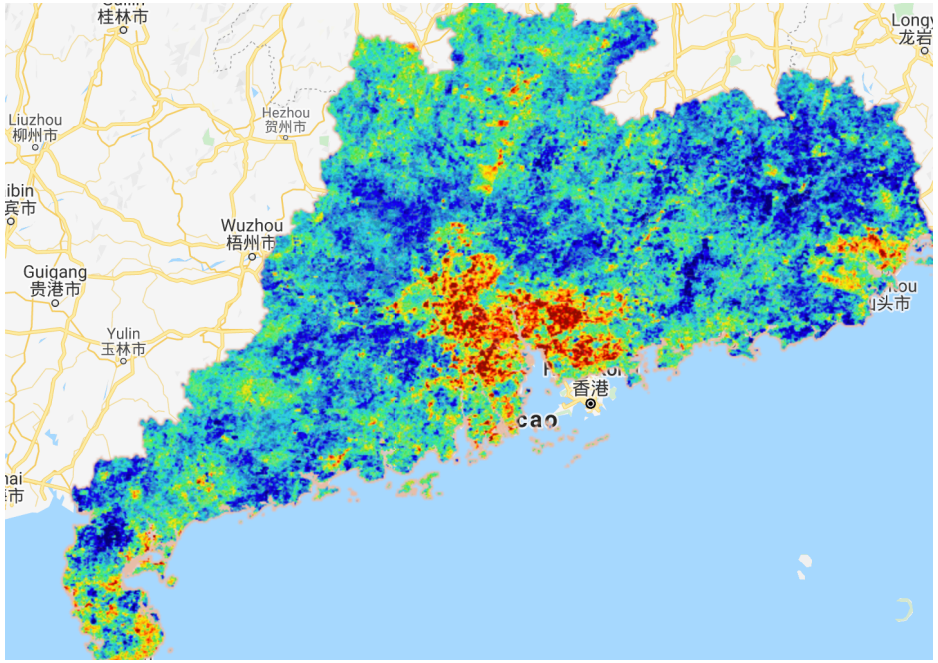
```
///there differen regions
function Buff(f){
var buffer9000 = f.buffer(9000);
return buffer9000;}
var point1 = ee.Geometry.Point([116.5635, 23.5787]); var point2 = ee.Geometry.Point([113.9209, 22.5979]);
var point3 = ee.Geometry.Point([113.9962, 24.8015]);
var Buffer1 = Buff(point1); var Buffer2 = Buff(point2); var Buffer3 = Buff(point3);
Map.addLayer(Buffer1,{color:'00FFFF'},'Buffer 1'); Map.addLayer(Buffer2,{color:'00FFFF'},'Buffer 2');
Map.addLayer(Buffer3,{color:'00FFFF'},'Buffer 3');
var buffer_collection=ee.FeatureCollection([ee.Feature(Buffer1,{'label':'buffer1'}),ee.Feature(Buffer2,{'label':'buffer2'}),
                                ee.Feature(Buffer3,{'label':'buffer3'})]);
var year_list=ee.List.sequence(2000,2019);
year_list=year_list.map(function(num){
var time=ee.Date.fromYMD(num, 1, 1)
  var year_image=ee.ImageCollection('MODIS/006/MOD13A1').filterDate(time,ee.Date(time).advance(1,'year')).max();
  var year_ndvi=year_image.select('NDVI');
  year_ndvi=year_ndvi.set({'system:time_start':ee.Date.fromYMD(num,1,1)})  return  year_ndvi;})
  var img_collection=ee.ImageCollection.fromImages(year_list);
var ndviTimeSeries = ui.Chart.image.seriesByRegion(
  img_collection, buffer_collection, ee.Reducer.mean(), 'NDVI',500,'system:time_start','label') .setOptions({
        vAxis: {title: 'NDVI*10000'},lineWidth: 1,pointSize: 4,
        series: { 0: {color: 'FF0000'}, 1: {color: '00FF00'},  2: {color: '0000FF'} }});
print(ndviTimeSeries)
```





Heat island effect

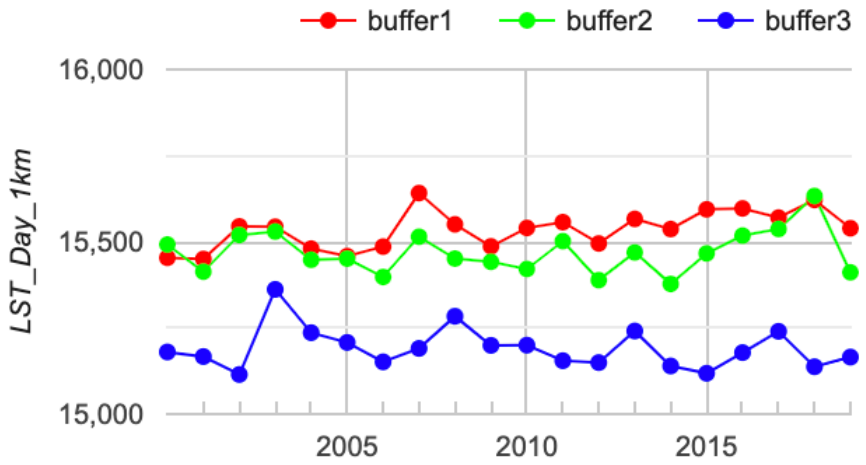
```
var year_list=ee.List.sequence(2000,2019);
year_list=year_list.map(function(num){
  var time=ee.Date.fromYMD(num, 1, 1)
  var year_image=ee.ImageCollection('MODIS/006/MOD11A1')
                .filterDate(time,ee.Date(time).advance(1,'year')).max();
  var year_ndvi=year_image.select('LST_Day_1km');
  return  year_ndvi.addBands(ee.Image.constant(num).toFloat());  })
var img_collection=ee.ImageCollection.fromImages(year_list);
var linearFit = img_collection.select(['constant', 'LST_Day_1km']).reduce(ee.Reducer.linearFit());
var trendVis = {
  min: -10,
  max: 12,
  palette: [
    '040274', '040281', '0502a3', '0502b8', '0502ce', '0502e6',
    '0602ff', '235cb1', '307ef3', '269db1', '30c8e2', '32d3ef',
    '3be285', '3ff38f', '86e26f', '3ae237', 'b5e22e', 'd6e21f',
    'fff705', 'ffd611', 'ffb613', 'ff8b13', 'ff6e08', 'ff500d',
    'ff0000', 'de0101', 'c21301', 'a71001', '911003']
};
Map.addLayer(linearFit.select('scale').clip(Guangdong),trendVis,'heat island');
```



The heat islands concentrate in the large cities Guangzhou and Shenzhen. However, in most remote areas, the temperature has a decreasing trend.

Heat island effect (three regions)

```
var year_list=ee.List.sequence(2000,2019);


year_list=year_list.map(function(num){
  var time=ee.Date.fromYMD(num, 1, 1)
  var year_image=ee.ImageCollection('MODIS/006/MOD11A1')
                .filterDate(time,ee.Date(time).advance(1,'year')).max();
  var year_lst=year_image.select('LST_Day_1km');
  year_lst=year_lst.set({'system:time_start':ee.Date.fromYMD(num,1,1)})
  return  year_lst;})
var img_collection=ee.ImageCollection.fromImages(year_list);


var ndviTimeSeries = ui.Chart.image.seriesByRegion(
  img_collection, buffer_collection, ee.Reducer.mean(), 'LST_Day_1km',500,'system:time_start','label')
        .setOptions({
        vAxis: {title: 'LST_Day_1km'},
        lineWidth: 1,
        pointSize: 4,
        series: {
          0: {color: 'FF0000'},
          1: {color: '00FF00'},
          2: {color: '0000FF'} }});
print(ndviTimeSeries)
```



Temperature fluctuates a lot. Shenzhen and Shantou have higher temperature than Shaoguan city.

CONCLUSION

- From the analysis above, we can see the patterns and effects of the Urban sprawl of Guangdong province. Consistent with the literature review, urban sprawl in Guangdong province is low-density urbanization. While the urban built-up area expands, the population mainly grows in the major cities and remain stable in newly urbanized areas. The effects of urban sprawl include decreasing natural land, a loss in vegetation(although big cities become greener these years), urban heat island effect, etc. Specifically, Shantou city draws my attention, since it's remote from the major cities but has an apparent trend of losing vegetation and increasing temperature.
- I think one way to solve urban sprawl is to pay attention to both the inner cities and the newly urbanized areas during the urbanization process. Further policy changes are necessary.

REFERENCE

- QI Lei, LU Bin. Urban sprawl: A case study of Shenzhen, China. 44th ISOCARP Congress 2008

Appendix: Full Google EE Code

```
var Guangdong = ee.FeatureCollection("users/zenithchenr/Guangdong");


/*PART1 NIGHT LIGHT*/
function createTimeBand(img) {
  var year = ee.Date(img.get('system:time_start')).get('year').subtract(2000);
  return ee.Image(year).byte().addBands(img);}
// Map the time band creation helper over the night-time lights collection.
var collection = ee.ImageCollection('NOAA/DMSP-OLS/NIGHTTIME_LIGHTS')
    .select('stable_lights')
    .map(createTimeBand);
var trend = collection.reduce(ee.Reducer.linearFit());
var trendClipped = trend.clip(Guangdong);
// Compute a linear fit over the series of values at each pixel, visualizing
// the y-intercept in green, and positive/negative slopes as red/blue.
Map.centerObject(Guangdong);
Map.addLayer(trendClipped, {min: 0, max: [0.18, 30, -0.18], bands: ['scale', 'offset', 'scale']}, 'stable lights trend');
//examine the four cities
var addname_gz = function(feature) {
  return feature.set({name: 'Guangzhou'});};
var addname_sz = function(feature) {
  return feature.set({name: 'Shenzhen'});};
var addname_zs = function(feature) {
  return feature.set({name: 'Zhongshan'});};
var addname_sg = function(feature) {
  return feature.set({name: 'Shaoguan'});};
var gz = Guangdong.filterMetadata('NAME_2','equals',('Guangzhou')).union().set('name', 'Guangzhou')
var gz_union = gz.map(addname_gz);
var sz = Guangdong.filterMetadata('NAME_2','equals',('Shenzhen')).union().set('name', 'Shenzhen')
var sz_union = sz.map(addname_sz);
var zs = Guangdong.filterMetadata('NAME_2','equals',('Zhongshan')).union().set('name', 'Zhongshan')
var zs_union = zs.map(addname_zs);
var sg = Guangdong.filterMetadata('NAME_2','equals',('Shaoguan')).union().set('name', 'Shaoguan')
var sg_union = sg.map(addname_sg);
var all = gz_union.merge(sz_union).merge(zs_union).merge(sg_union);
Map.addLayer(zs_union,{color:'ebbdab'},'four cities');
var light13 = ee.Image('NOAA/DMSP-OLS/NIGHTTIME_LIGHTS/F182013').select('stable_lights').clip(all);
var nighttimeLightsVis = { min: 3.0, max: 60.0,};
Map.addLayer(light13,nighttimeLightsVis,'2013 Lights');
var TheCHART4 = ui.Chart.image.byRegion(light13,all,ee.Reducer.mean(),300,'name');
var TheCHART4 = TheCHART4.setChartType('ColumnChart').setOptions({title:'Mean nightlight value by County',
hAxis:{title:'City'},vAxis:{ title: 'nightlight'} });
print(TheCHART4);
```

Appendix: Full Google EE Code

```
/*PART2 Population*/
var year_list=ee.List.sequence(2000,2019);
year_list=year_list.map(function(num){
 var time=ee.Date.fromYMD(num, 1, 1)
 var year_image=ee.ImageCollection('WorldPop/GP/100m/pop')
              .filterDate(time,ee.Date(time).advance(1,'year')).max();
 var year_ndvi=year_image.select('population');
 return  year_ndvi.addBands(ee.Image.constant(num).toFloat());      } )
var img_collection=ee.ImageCollection.fromImages(year_list);
print(img_collection)
var linearFit = img_collection.select(['constant', 'population']).reduce(ee.Reducer.linearFit());
var trendVis = {min: -6,max: 6,
 palette: [
   '040274', '040281', '0502a3', '0502b8', '0502ce', '0502e6',
   '0602ff', '235cb1', '307ef3', '269db1', '30c8e2', '32d3ef',
   '3be285', '3ff38f', '86e26f', '3ae237', 'b5e22e', 'd6e21f',
   'fff705', 'ffd611', 'ffb613', 'ff8b13', 'ff6e08', 'ff500d',
   'ff0000', 'de0101', 'c21301', 'a71001', '911003']};
Map.addLayer(linearFit.select('scale').clip(Guangdong),trendVis,'population trend’);

/*Part3 land cover*/
var landuse2010_original = ee.Image('MODIS/051/MCD12Q1/2013_01_01').select('Land_Cover_Type_1');
var landuse2001_original = ee.Image('MODIS/051/MCD12Q1/2001_01_01').select('Land_Cover_Type_1')
var landuse2010_clip = landuse2010_original.clip(Guangdong);
var landuse2001_clip = landuse2001_original.clip(Guangdong);

var ColorsForMODIS = ['aec3d4', // 00 = Water
'33510d', // 01 = Forest
'e2720f', // 02 =
'369b47', // 03 = Deciduous Needleleaf Forest
'30eb5b', // 04 = Deciduous Broadleaf Forest
'387242', // 05 = Mixed Deciduous Forest
'ff6100', // 06 = Closed Shrubland
'c3aa69', // 07 = Open Shrubland
'b76031', // 08 = Woody Savanna
'd9903d', // 09 = Savanna
'a9c952', // 10 = Grassland
'111149', // 11 = Permanent Wetland
'cdb33b', // 12 = Cropland
'c40f5a', // 13 = Urban
'33280d', // 14 = Crops & Natural Vegetation
'd7cdcc', // 15 = Permanent Snow & Ice
'f7e084', // 16 = Barren / Desert
'6f6f6f' // 17 = Unclassified
].join(',');

var landuse2010 = landuse2010_clip.remap( [0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17],
[1,4,1,1,1,1,1,1,1,1,1,2,2,1,1,1,4], 0, 'Land_Cover_Type_1');
var landuse2001 = landuse2001_clip.remap( [0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17],
[1,4,1,1,1,1,1,1,1,1,1,2,2,1,1,1,4], 0, 'Land_Cover_Type_1');
```

Appendix: Full Google EE Code

```
Map.addLayer(landuse2001,{ min:0, max:17, palette:ColorsForMODIS },'LU2001');
Map.addLayer(landuse2010,{ min:0, max:17, palette:ColorsForMODIS },'LU2010');
//Identify land use changes between 2001 and 2010
var type_change = landuse2010.subtract(landuse2001);
var type_change_abs = type_change.abs();
// Land use changing from the natural to the urban(cropland);
var UrbantoNature = type_change.remap([0,1,2,3,-1,-2,-3],[0,0,0,0,1,0,0],0);
Map.addLayer (UrbantoNature, {opacity:0.7}, 'Urban to Nature' );

/*PART4 NDVI*/
var year_list=ee.List.sequence(2000,2019);
year_list=year_list.map(function(num){
 var time=ee.Date.fromYMD(num, 1, 1)
 var year_image=ee.ImageCollection('MODIS/006/MOD13A1')
              .filterDate(time,ee.Date(time).advance(1,'year')).max();
 var year_ndvi=year_image.select('NDVI');
 return  year_ndvi.addBands(ee.Image.constant(num).toFloat());            })
var img_collection=ee.ImageCollection.fromImages(year_list);
var linearFit = img_collection.select(['constant', 'NDVI']).reduce(ee.Reducer.linearFit());
var trendVis = {min: -100, max: 100,
 palette: [
   '040274', '040281', '0502a3', '0502b8', '0502ce', '0502e6',
   '0602ff', '235cb1', '307ef3', '269db1', '30c8e2', '32d3ef',
   '3be285', '3ff38f', '86e26f', '3ae237', 'b5e22e', 'd6e21f',
   'fff705', 'ffd611', 'ffb613', 'ff8b13', 'ff6e08', 'ff500d',
   'ff0000', 'de0101', 'c21301', 'a71001', '911003']};
Map.addLayer(linearFit.select('scale').clip(Guangdong),trendVis);
var gz = Guangdong.filterMetadata('NAME_2','equals',('Guangzhou')).union().set('name', 'Guangzhou')
var gz_union = gz.map(addname_gz);
var sz = Guangdong.filterMetadata('NAME_2','equals',('Shenzhen')).union().set('name', 'Shenzhen')
var sz_union = sz.map(addname_sz);
var zs = Guangdong.filterMetadata('NAME_2','equals',('Zhongshan')).union().set('name', 'Zhongshan')
var zs_union = zs.map(addname_zs);
var sg = Guangdong.filterMetadata('NAME_2','equals',('Shaoguan')).union().set('name', 'Shaoguan')
var sg_union = sg.map(addname_sg);
var all = gz_union.merge(sz_union).merge(zs_union).merge(sg_union);
Map.addLayer(zs_union,{color:'ebbdab'},'four cities');
var light13 = ee.Image('NOAA/DMSP-OLS/NIGHTTIME_LIGHTS/F182013').select('stable_lights').clip(all);
var nighttimeLightsVis = { min: 3.0, max: 60.0,};
Map.addLayer(light13,nighttimeLightsVis,'2013 Lights');
var TheCHART4 = ui.Chart.image.byRegion(light13,all,ee.Reducer.mean(),300,'name');
var TheCHART4 = TheCHART4.setChartType('ColumnChart').setOptions({title:'Mean nightlight value by County',
hAxis:{title:'City'},vAxis:{ title: 'nightlight'} });
print(TheCHART4);
```

Appendix: Full Google EE Code

```
Map.addLayer(landuse2001,{ min:0, max:17, palette:ColorsForMODIS },'LU2001');
Map.addLayer(landuse2010,{ min:0, max:17, palette:ColorsForMODIS },'LU2010');
//Identify land use changes between 2001 and 2010
var type_change = landuse2010.subtract(landuse2001);
var type_change_abs = type_change.abs();
// Land use changing from the natural to the urban(cropland);
var UrbantoNature = type_change.remap([0,1,2,3,-1,-2,-3],[0,0,0,0,1,0,0],0);
Map.addLayer (UrbantoNature, {opacity:0.7}, 'Urban to Nature' );


/*PART4 NDVI*/
var year_list=ee.List.sequence(2000,2019);
year_list=year_list.map(function(num){
 var time=ee.Date.fromYMD(num, 1, 1)
 var year_image=ee.ImageCollection('MODIS/006/MOD13A1')
              .filterDate(time,ee.Date(time).advance(1,'year')).max();
 var year_ndvi=year_image.select('NDVI');
 return  year_ndvi.addBands(ee.Image.constant(num).toFloat());            })
var img_collection=ee.ImageCollection.fromImages(year_list);
var linearFit = img_collection.select(['constant', 'NDVI']).reduce(ee.Reducer.linearFit());
var trendVis = {min: -100, max: 100,
 palette: [
   '040274', '040281', '0502a3', '0502b8', '0502ce', '0502e6',
   '0602ff', '235cb1', '307ef3', '269db1', '30c8e2', '32d3ef',
   '3be285', '3ff38f', '86e26f', '3ae237', 'b5e22e', 'd6e21f',
   'fff705', 'ffd611', 'ffb613', 'ff8b13', 'ff6e08', 'ff500d',
   'ff0000', 'de0101', 'c21301', 'a71001', '911003']};
Map.addLayer(linearFit.select('scale').clip(Guangdong),trendVis);
///there differen regions
function Buff(f){
var buffer9000 = f.buffer(9000);
return buffer9000;}
var point1 = ee.Geometry.Point([116.5635, 23.5787]);
var point2 = ee.Geometry.Point([113.9209, 22.5979]);
var point3 = ee.Geometry.Point([113.9962, 24.8015]);
var Buffer1 = Buff(point1);
var Buffer2 = Buff(point2);
var Buffer3 = Buff(point3);
Map.addLayer(Buffer1,{color:'00FFFF'},'Buffer 1');
Map.addLayer(Buffer2,{color:'00FFFF'},'Buffer 2');
Map.addLayer(Buffer3,{color:'00FFFF'},'Buffer 3');
var buffer_collection=ee.FeatureCollection([ee.Feature(Buffer1,{'label':'buffer1'}),
                                            ee.Feature(Buffer2,{'label':'buffer2'}),
                                             ee.Feature(Buffer3,{'label':'buffer3'})]);
```

Appendix: Full Google EE Code

```
var year_list=ee.List.sequence(2000,2019);
year_list=year_list.map(function(num){
 var time=ee.Date.fromYMD(num, 1, 1)
 var year_image=ee.ImageCollection('MODIS/006/MOD13A1')
            .filterDate(time,ee.Date(time).advance(1,'year')).max();
 var year_ndvi=year_image.select('NDVI');
 year_ndvi=year_ndvi.set({'system:time_start':ee.Date.fromYMD(num,1,1)})
 return  year_ndvi;})
var img_collection=ee.ImageCollection.fromImages(year_list);
var ndviTimeSeries = ui.Chart.image.seriesByRegion(
 img_collection, buffer_collection, ee.Reducer.mean(), 'NDVI',500,'system:time_start','label')
      .setOptions({vAxis: {title: 'NDVI*10000'},lineWidth: 1,pointSize: 4,
      series: {
        0: {color: 'FF0000'},
        1: {color: '00FF00'},
        2: {color: '0000FF'} }});
print(ndviTimeSeries)

/*PART5 heat island*/
var year_list=ee.List.sequence(2000,2019);
year_list=year_list.map(function(num){
 var time=ee.Date.fromYMD(num, 1, 1)
 var year_image=ee.ImageCollection('MODIS/006/MOD11A1')
            .filterDate(time,ee.Date(time).advance(1,'year')).max();
 var year_ndvi=year_image.select('LST_Day_1km');
 return  year_ndvi.addBands(ee.Image.constant(num).toFloat());  })
var img_collection=ee.ImageCollection.fromImages(year_list);
var linearFit = img_collection.select(['constant', 'LST_Day_1km']).reduce(ee.Reducer.linearFit());
var trendVis = {
 min: -10,  max: 12,
 palette: [
  '040274', '040281', '0502a3', '0502b8', '0502ce', '0502e6',
  '0602ff', '235cb1', '307ef3', '269db1', '30c8e2', '32d3ef',
  '3be285', '3ff38f', '86e26f', '3ae237', 'b5e22e', 'd6e21f',
  'fff705', 'ffd611', 'ffb613', 'ff8b13', 'ff6e08', 'ff500d',
  'ff0000', 'de0101', 'c21301', 'a71001', '911003']};
Map.addLayer(linearFit.select('scale').clip(Guangdong),trendVis,'heat island');
//three areas
var year_list=ee.List.sequence(2000,2019);
year_list=year_list.map(function(num){
 var time=ee.Date.fromYMD(num, 1, 1)
 var year_image=ee.ImageCollection('MODIS/006/MOD11A1')
            .filterDate(time,ee.Date(time).advance(1,'year')).max();
 var year_lst=year_image.select('LST_Day_1km');
 year_lst=year_lst.set({'system:time_start':ee.Date.fromYMD(num,1,1)})
 return  year_lst;})
```

Appendix: Full Google EE Code

```
var img_collection=ee.ImageCollection.fromImages(year_list);
var ndviTimeSeries = ui.Chart.image.seriesByRegion(
  img_collection, buffer_collection, ee.Reducer.mean(), 'LST_Day_1km',500,'system:time_start','label')
        .setOptions({
        vAxis: {title: 'LST_Day_1km'}, lineWidth: 1,pointSize: 4,
        series: {
          0: {color: 'FF0000'},
          1: {color: '00FF00'},
          2: {color: '0000FF'} }});
print(ndviTimeSeries)
```

Code link:

https://code.earthengine.google.com/214639d906dc4f15f574bb3473f955a7