Where are the World's Best Coffee-growing Regions?

Introduction

Coffee has become one of the most popular drinks around the world. Coffee planting is a very important rural economics for many tropical countries. The script is exploring the best coffee-growing regions around the world. Sun, water, soil, and air are essentials for coffee bean being able to thrive. The four combine provides the plant with the energy and nutrients necessary to sustain life. Otherwise, coffee planting has certain requirements for external surroundings and are dependent on soil, weather, microorganisms, temperature, humidity, and myriad other influences. The project will take all the factors into consideration and select the most suitable regions for coffee bean growing.

Essential Conditions for Growing Coffee Beans

Essentials	Best Coffee-growing Conditions
Temperature	Averages range from 15 - 30 deg C

Rainfall	Averages between 1,500 to 2,500 mm per year
Elevation	Range from 800 - 1800 meter
Slope	Gentle slopes (below 40 degree)
Aspect	Facing north, east or a north-easterly direction Cool, shaded, or semi-shaded and moist environment
Soil	Slightly acidic soil is favorable for growing coffee (a pH of 4.9-7)
	Relative humidity in maintained in the 40–90% range. Well-drained, deep, friable, and rich in organic

Overview

1. Import the data

```
// Import the data
// Daily mean 2m air temperature
var temperature = ee.ImageCollection('ECMWF/ERA5/DAILY')
                .filterDate('2019-07-01', '2020-07-01')
                .select('mean_2m_air_temperature');

// Daily total precipitation sums
var precipitation = ee.ImageCollection('ECMWF/ERA5/DAILY')
                .filterDate('2019-07-01', '2020-07-01')
                .select('total_precipitation');

// Elevation
var elevation = ee.Image('CGIAR/SRTM90_V4')
                .select('elevation');

// Soil PH at 10cm depth
var SoilPH = ee.Image("OpenLandMap/SOL/SOL_PH-H2O_USDA-
4C1A2A_M/v02").select('b10');

// Soil Moisture
var SoilMoisture = ee.ImageCollection('NASA/GLDAS/V021/NOAH/G025/T3H')
                .filterDate('2020-07-01', '2020-07-02')
                .select('RootMoist_inst');
```

2. Select the regions with temperature range from 15 to 30 degree C.

```
// Temperature
// Calculate the average temperature over the year
```

```javascript
var TemperatureMean = temperature.mean( );
// print(TemperatureMean);
print(temperature);

// Transfer the temperature unit from Kelvin to Celsius
var TemperatureMeanC = TemperatureMean.subtract(273.15)

// Select the terrain
var landcover = ee.Image("COPERNICUS/Landcover/100m/Proba-V-C3/Global/2019")
.select('discrete_classification');
var terrain = landcover.neq(200)
var TemperatureTerrain = TemperatureMeanC.updateMask(terrain)

// Select the area with average temperature range from 15 to 30 degrees celsius
var Temperature15 = TemperatureMeanC.gt(15)
var Temperature30 = TemperatureMeanC.lt(30)
var Temperature1530 = Temperature15.and(Temperature30)
var TemperatureCoffee = TemperatureTerrain.mask(Temperature1530)

// Visualization palette for temperature
// temperature
var TemperatureVis = {
  min: -23.15,
  max: 46.85,
  palette: [
    '#000080', '#0000D9', '#4000FF', '#8000FF', '#0080FF', '#00FFFF', '#00FF80',
    '#80FF00', '#DAFF00', '#FFFF00', '#FFF500', '#FFDA00', '#FFB000', '#FFA400',
    '#FF4F00', '#FF2500', '#FF0A00', '#FF00FF'
  ]
};

// Add layer to map
Map.setCenter(21.2, 22.2, 2);
Map.addLayer(
    TemperatureTerrain, TemperatureVis,
    'Annual Average Temperatures 2M Air Temperature');
Map.addLayer(
    TemperatureCoffee, TemperatureVis,
    'Areas with teperature good for coffee growing');
```
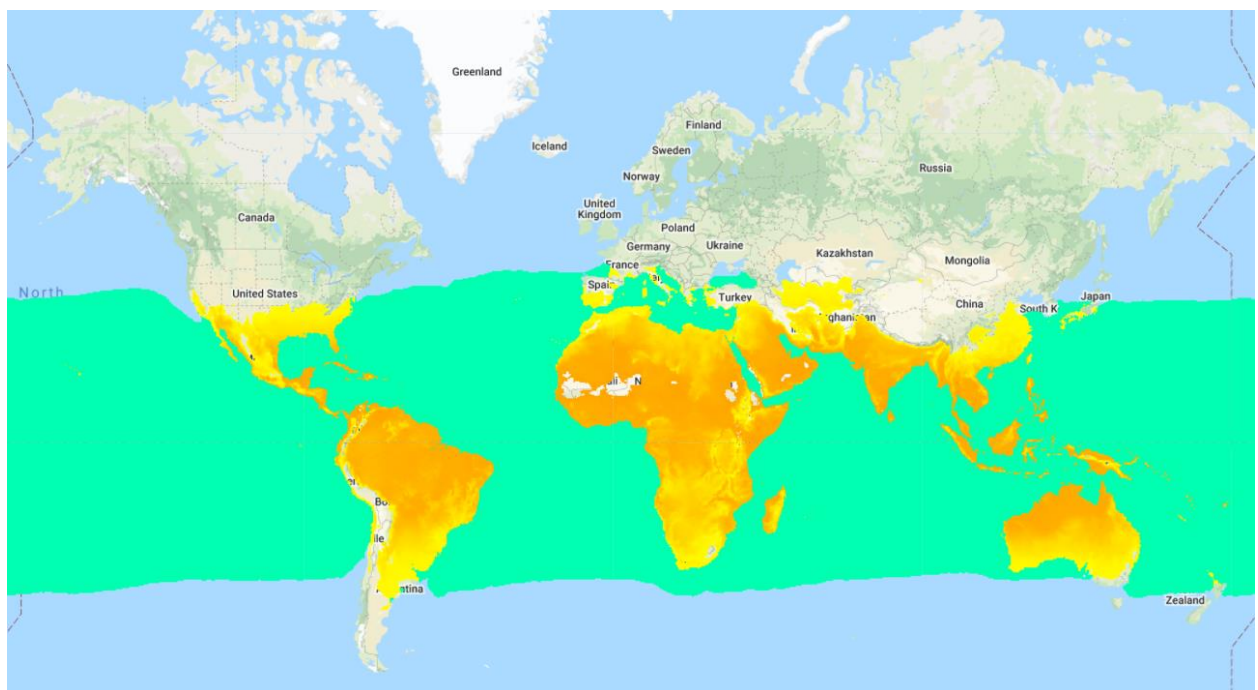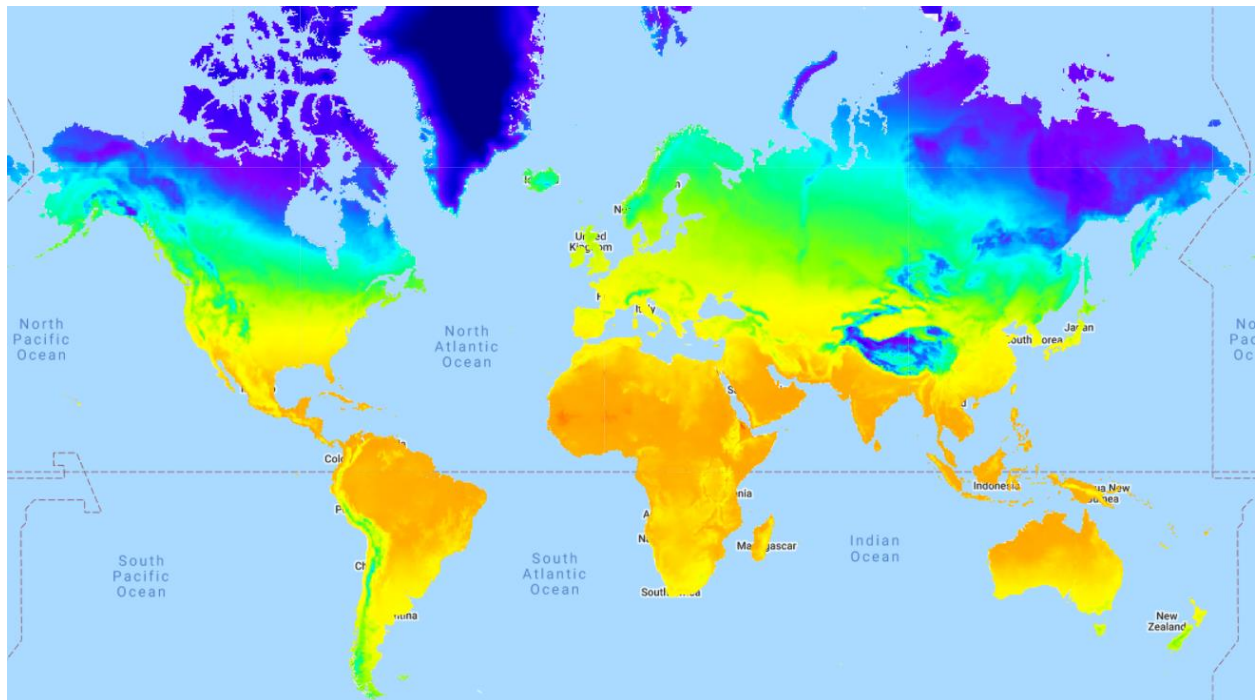
3. Select the regions with the annual average precipitation ranges from 1,500 to 2,500 mm.

```javascript
// Rainfall
// Calculate the average temperature over the year
var RainYearSum = precipitation.sum( );

// Select the terrain
var landcover = ee.Image("COPERNICUS/Landcover/100m/Proba-V-C3/Global/2019")
.select('discrete_classification');
var terrain = landcover.neq(200);
var RainYearSumTerrain = RainYearSum.updateMask(terrain);

// Select the areas that annual rainfall range from 1500 to 2500mm
var Rain1500 = RainYearSum.gt(1.5);
var Rain2500 = RainYearSum.lt(2.5);
var Rain1525 = Rain1500.and(Rain2500);
var RainCoffee = RainYearSumTerrain.updateMask(Rain1525)

// Visualization palette for total precipitation
var RainVis = {
  palette: ['ab0000', 'ff0000', 'ca531a', 'ff7c1f', 'ffa12d', 'ffc969', 'ffe6a2',

  'fdffb4', 'e5f9ff', 'caebff', 'acd1ff', '8dbae9', '5699ff', '2955bc', '1a3678']
};
// Add layer to map
Map.addLayer(
    RainYearSumTerrain, RainVis,
    'Annual average precipitation');

Map.addLayer(
    RainCoffee, {palette:'5e60ce'},
    'Annual average precipitation range from 1500to 2500mm ');
```
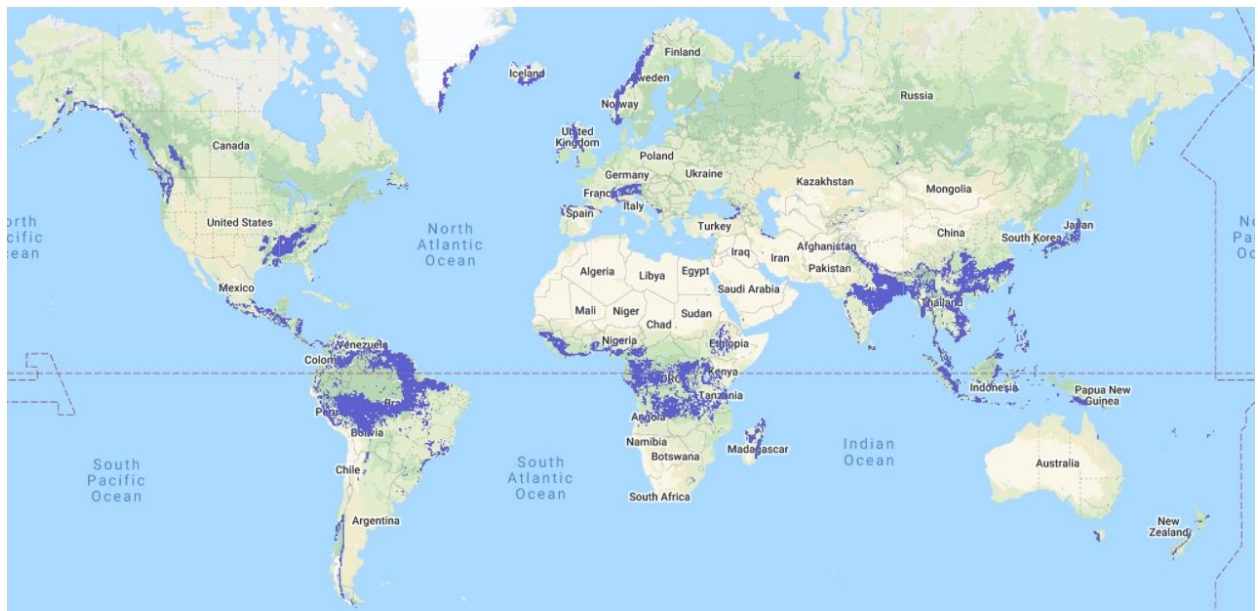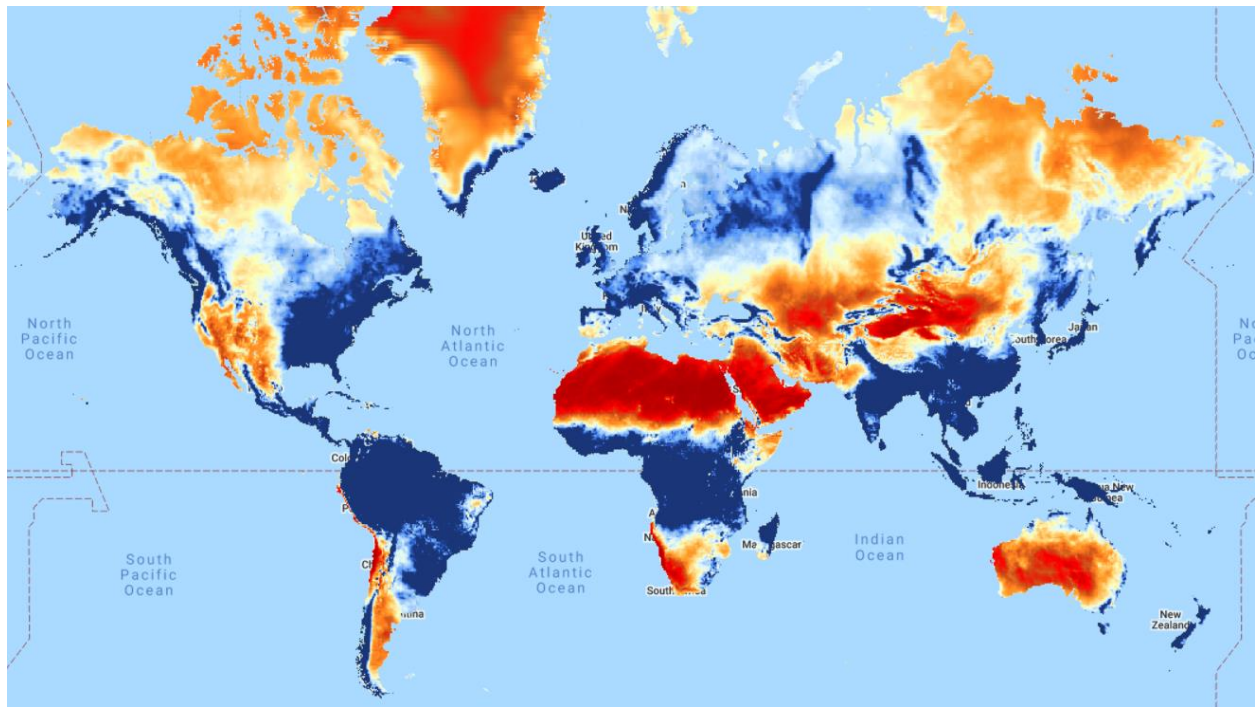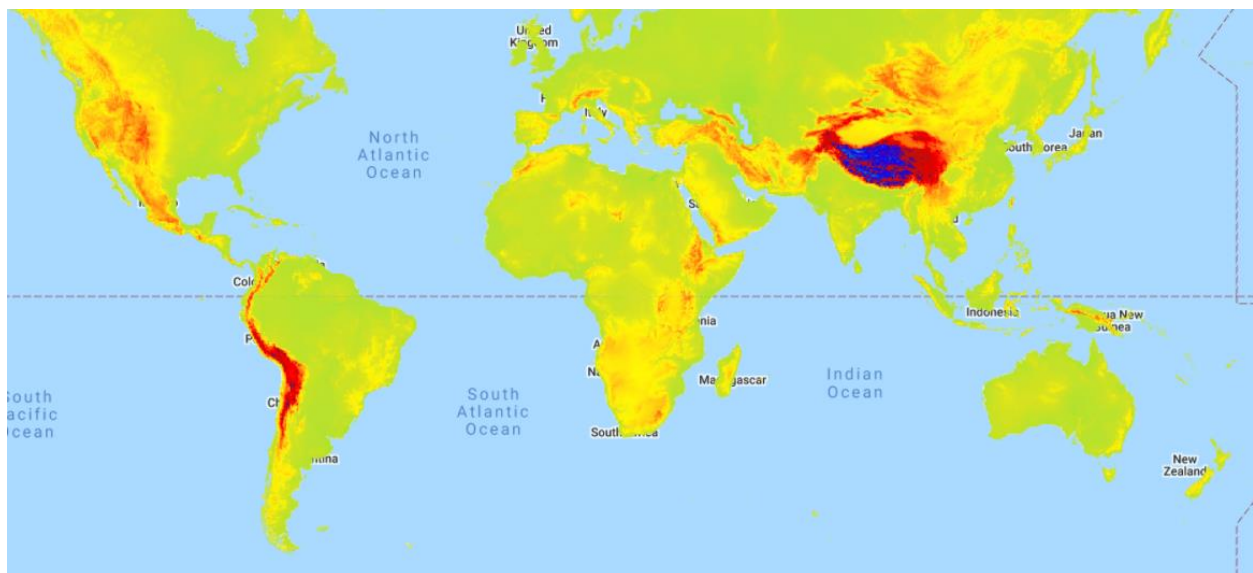
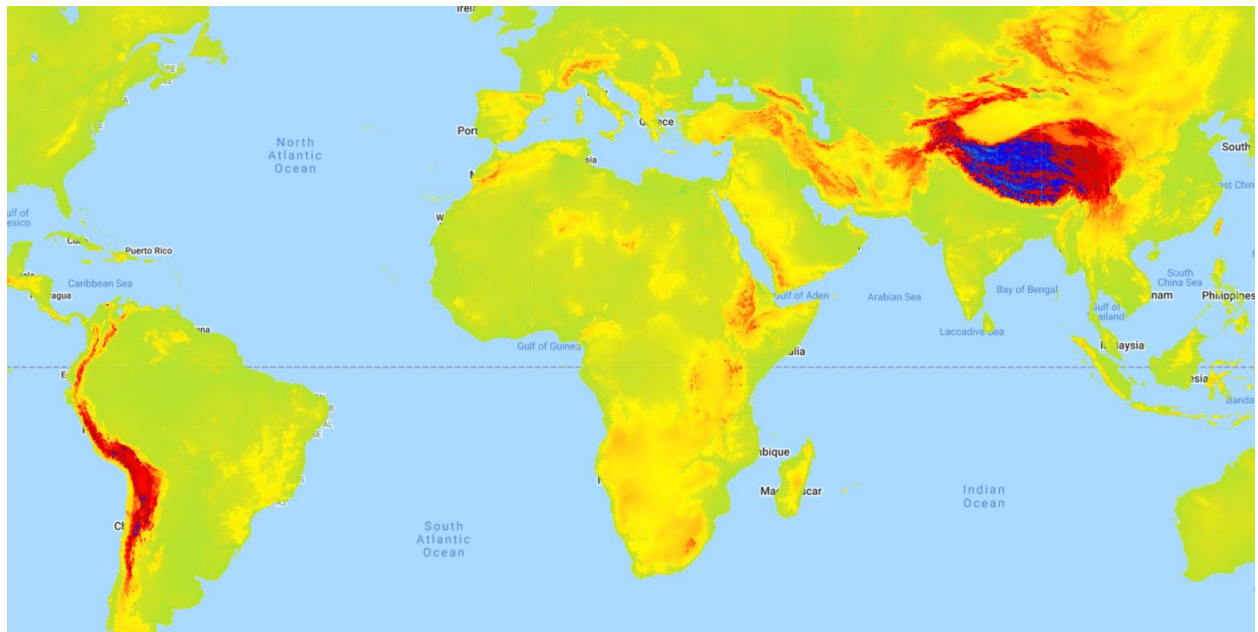4. Select the regions with elevation range from 800 to 1800 meter.

```
// Elevation
// Select the areas with elevation range from 800 to 1800 meter
var Elevation800 = elevation.gt(800);
var Elevation1800 = elevation.lt(1800);
var Elevation818 = Elevation800.and(Elevation1800);
var ElevationCoffee = elevation.updateMask(Elevation818)

// Making the Elevation more smooth
var ElevationSmooth = ElevationCoffee.reduceNeighborhood( ee.Reducer.mean( ), ee.
Kernel.circle( 4 ) );

// Visualization palette for elevation
var ElevationVis = {
  min: -444,
  max: 8806,
  palette: ['3ae237', 'b5e22e', 'd6e21f', 'fff705', 'ffd611', 'ffb613', 'ff8b13',
    'ff6e08', 'ff500d', 'ff0000', 'de0101', 'c21301', '0602ff', '235cb1',
    '307ef3', '269db1', '30c8e2', '32d3ef', '3be285', '3ff38f', '86e26f'
  ]
};

// Add layer to map
Map.addLayer(elevation, ElevationVis, 'Elevation');
Map.addLayer(ElevationCoffee, ElevationVis, 'Elevation range from 800 to 1800 met
er');
Map.addLayer(ElevationSmooth, ElevationVis, 'Smoothed Elevation');
```

5. Select the regions with the slop less than 60 degree.

```javascript
// Slop
var slope = ee.Terrain.slope(elevation);

// Select the areas with slope less than 60 degree
var Slope40 = slope.lt(40)
var SlopeCoffee = slope.updateMask(Slope40)

// Visualization palette for elevation
var ElevationVis = {
  min: 0,
  max: 90,
  gamma: 9
};

// Add the layer to the map
Map.addLayer(slope, ElevationVis, 'slope');
Map.addLayer(SlopeCoffee, {paltte: 'green'}, 'Slope Less Than 40 Degree');
```
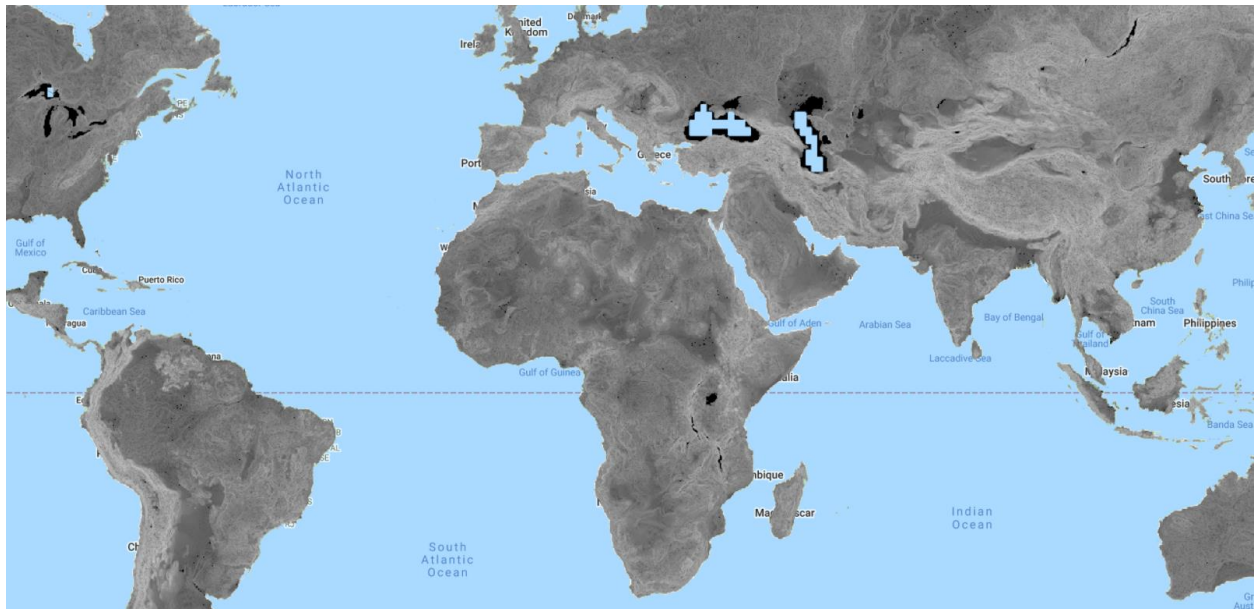
6. Select the regions with the aspect facing north or east, or north-east.

```
// Aspect
var aspect = ee.Terrain.aspect(elevation);

// Select regions with aspect facing north,east, or north-east
var AspectNorth = aspect.gt(0);
var AspectEast = aspect.lt(90);
var AspectNorthEast = AspectNorth.and(AspectEast);
var AspectCoffee = aspect.updateMask(AspectNorthEast)

// Add the Layer to the map
Map.addLayer(aspect, {gamma:1}, 'Aspect');
Map.addLayer(AspectCoffee, {gamma:1}, 'Aspect Facing North-east');
```
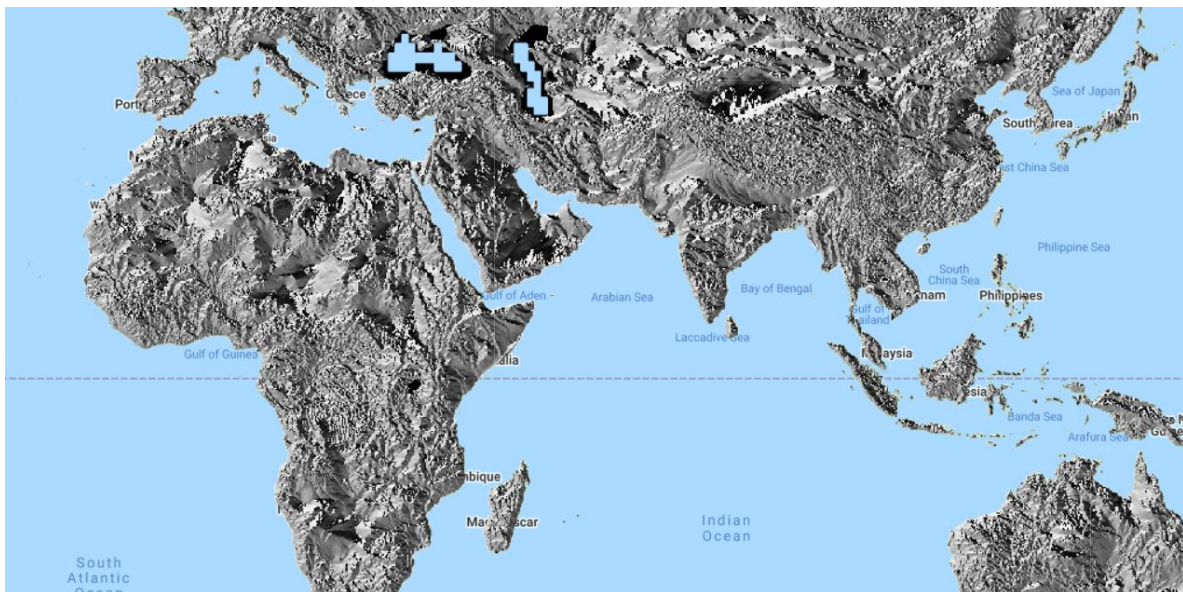
7. Select regions with suitable soil PH.

```
// Soil
// Soil PH
// Select the regions with soil at a PH of 4 to 7
var Soil5 = SoilPH.gt(49);
var Soil7 = SoilPH.lt(70);
var Soil57 = Soil5.and(Soil7);
var SoilCoffee = soil.updateMask(Soil57);

// Visualization palette for soil PH
var SoilPHVis = {
  min: 42.0,
  max: 110.0,
  palette: [
    "FF0000","FF1C00","FF3900","FF5500","FF7100","FF8E00",
    "FFAA00","FFC600","FFE200","FFFF00","E3FF00","C7FF00",
    "AAFF00","8EFF00","72FF00","55FF00","39FF00","1DFF00",
    "01FF00","00FF1C","00FF38","00FF54","00FF71","00FF8D",
    "00FFA9","00FFC6","00FFE2","00FFFE","00E3FF","00C7FF",
    "00ABFF","008FFF","0072FF","0056FF","003AFF","001DFF",
    "0001FF","1B00FF","3800FF","5400FF",
  ]
};

// Add the layers to the map
Map.centerObject(soil);
Map.addLayer(SoilPH, SoilPHVis, "Soil pH x 10 in H2O");
Map.addLayer(SoilCoffee, SoilPHVis, "Soil PH between 4.9 to 7");
```
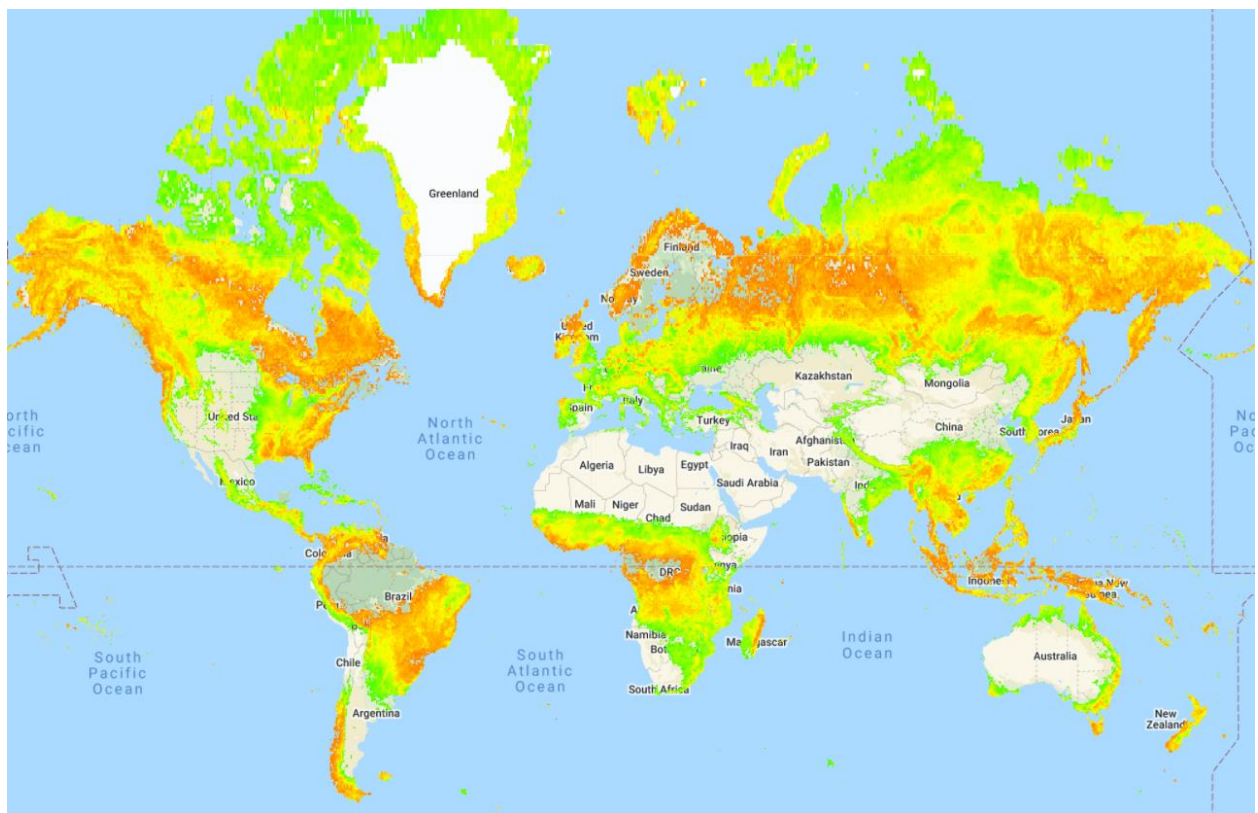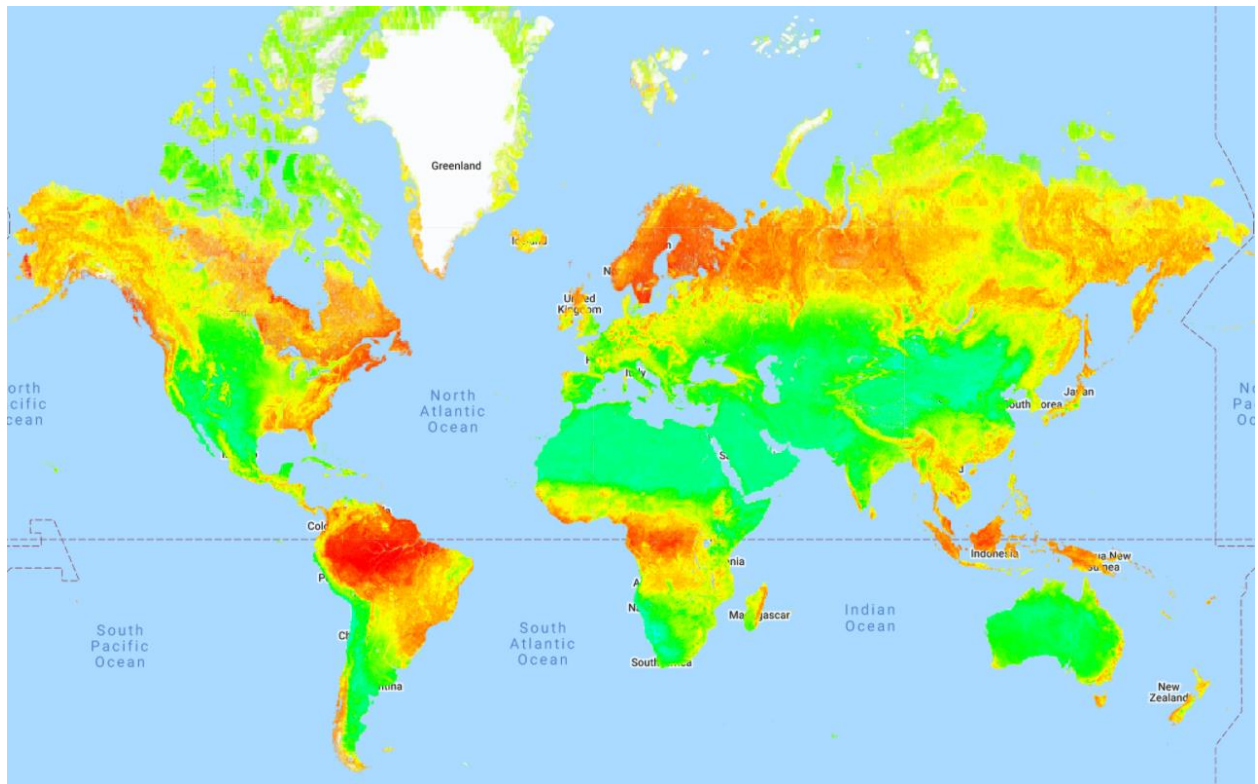
8. Select the regions that relative humidity of soil ranges from 40% to 80%.

```
/ Soil moisture
var SoilMoisture1 = SoilMoisture.first( );

// Select the regions with soil relative humidity ranges from 40% to 80%
var SoilMoisture40 = SoilMoisture1.gt(379.04);
var SoilMoisture80 = SoilMoisture1.lt(852.84);
var SoilMoisture4080 = SoilMoisture40.and(SoilMoisture80);
var SoilMoistureCoffee = SoilMoisture1.updateMask(SoilMoisture4080);

// Visualization palette for soil relative humidity
var SoilMoistureVis = {
  min: 2,
  max: 949.6,
  palette: ['1303ff', '42fff6', 'f3ff40', 'ff5d0f'],
};

// Add the layers to the map.
Map.addLayer(SoilMoisture, SoilMoistureVis, 'Soil Moisture');
Map.addLayer(SoilMoistureCoffee, SoilMoistureVis, 'Soil Reletive Humidity Ranges
from 40% to 80%');
```
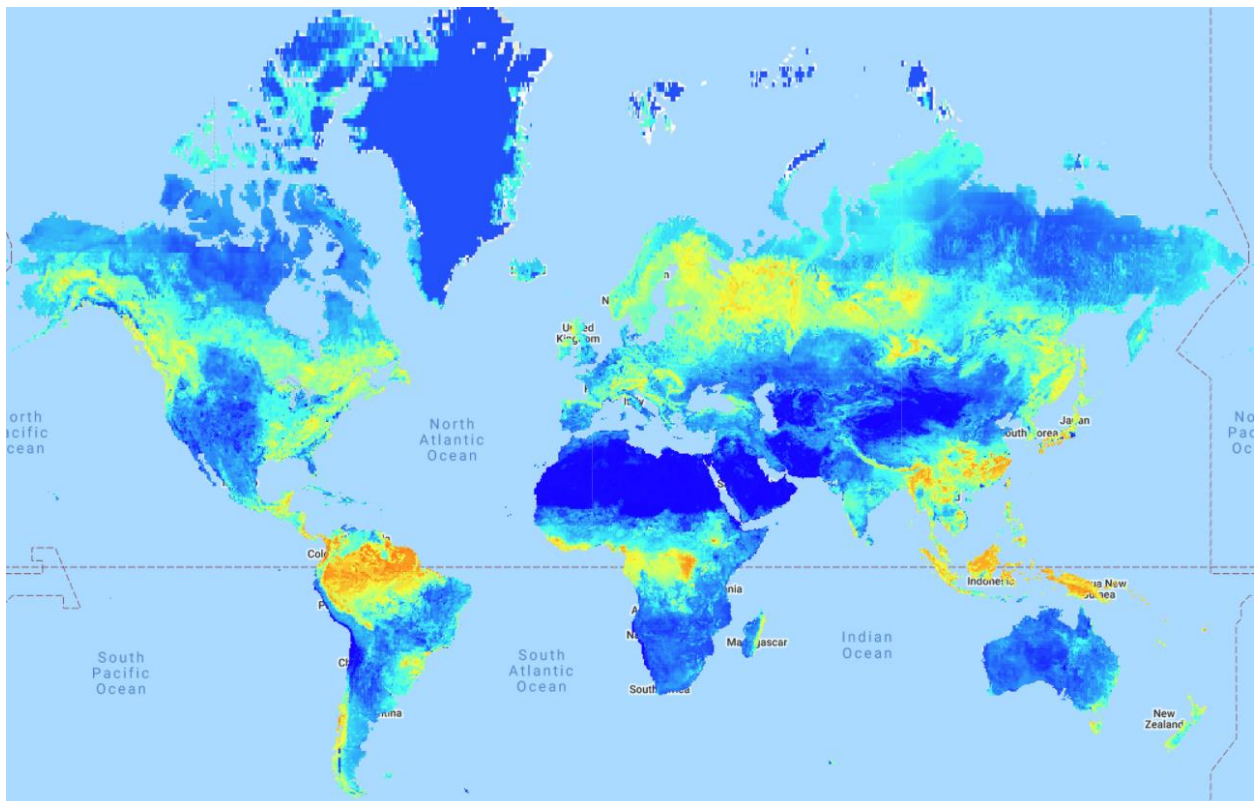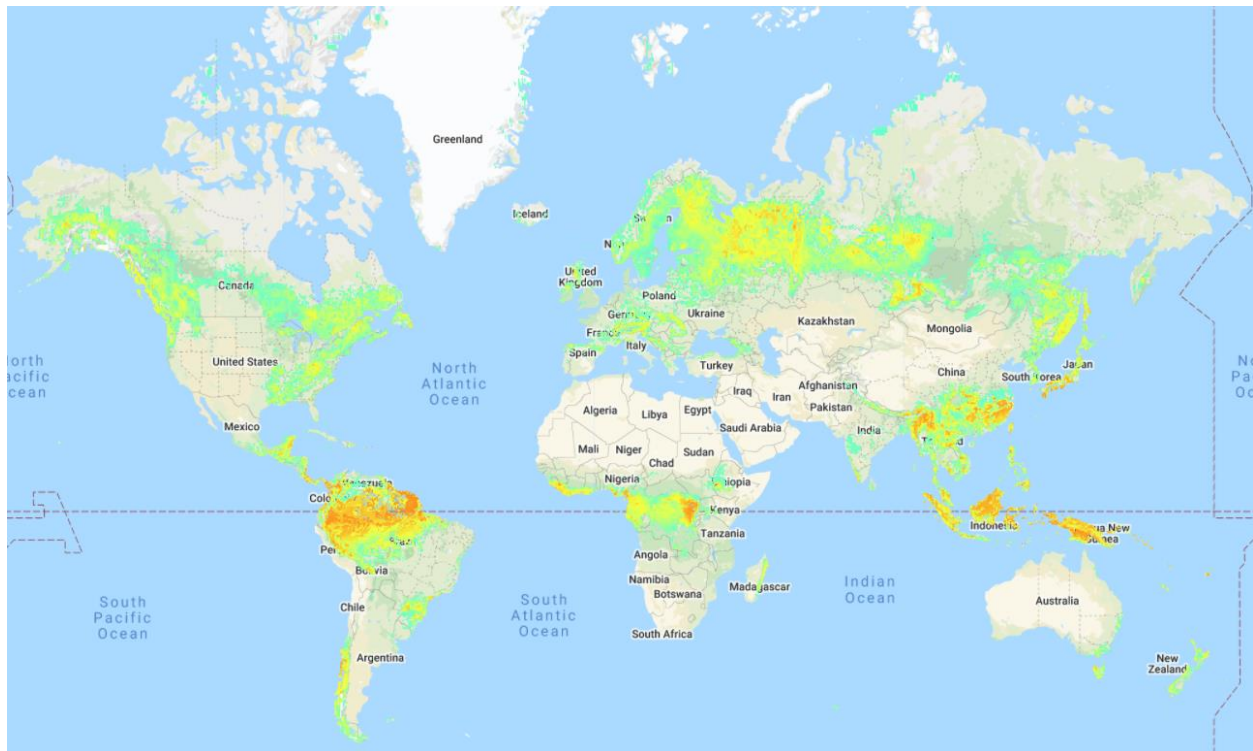
9. Finally, select the regions that satisfied all the conditions.

```
// Select the regions that satisfied all the coffee growing condtions
var CoffeeGrowingRegions = TemperatureCoffee.and(RainCoffee).and(ElevationCoffee)
.and(SlopeCoffee).and(AspectCoffee).and(SoilCoffee).and(SoilMoistureCoffee);
Map.addLayer(CoffeeGrowingRegions, null, 'Best Coffee Growing Regions');
```

As the figures shown, the best coffee growing regions are in the tropics and subtropics. Asia and Pacific countries from Indonesia, China, Papua New Guinea to Vietnam, Thailand and India, Africa countries include Ethiopia, Kenya, Rwanda, Cameroon, Madagascar and Ugenda, Latin America countries include Mexico, Guatemala, Costa Rica, Colombia and Peru, Boliva are homes for high quality coffee. These regions are good for coffee growing with the advantaged natural condition.
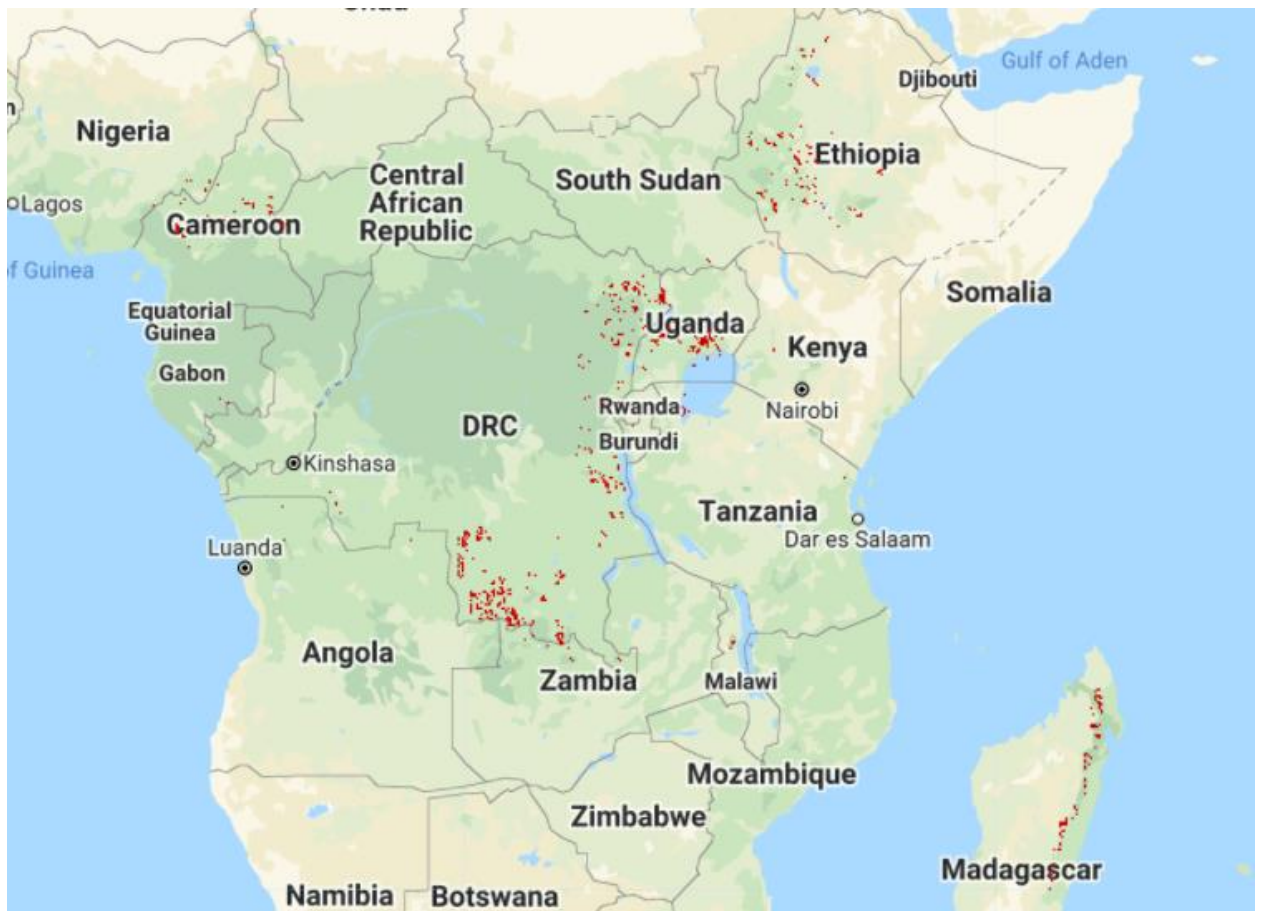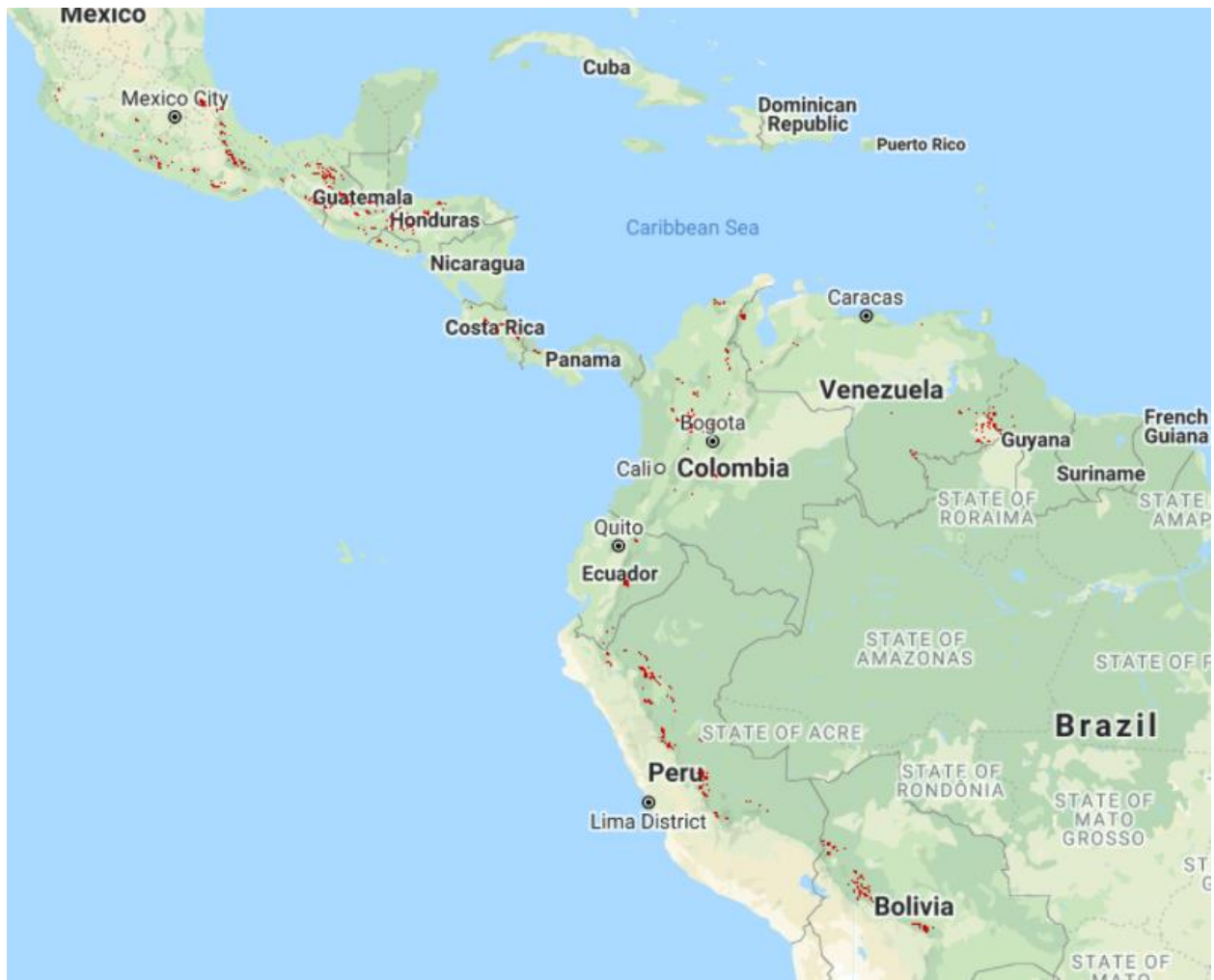
Reference

A Coffee Producer's Guide to Soil Management & Farm Conditions:
https://perfectdailygrind.com/2017/11/a-coffee-producers-guide-to-soil-management-farm-conditions/

What are the best conditions for growing coffee? https://www.quora.com/What-are-the-best-conditions-for-growing-coffee

Basic Plant Biology: Keeping the Coffee Plant "Happy": https://scanews.coffee/2014/03/08/science-basic-plant-biology-keeping-the-coffee-plant-happy/

Climate & Coffee: https://www.climate.gov/news-features/climate-and/climate-coffee

Code Link

https://code.earthengine.google.com/7554299bdc0980aa38eaedf0c1597b2e