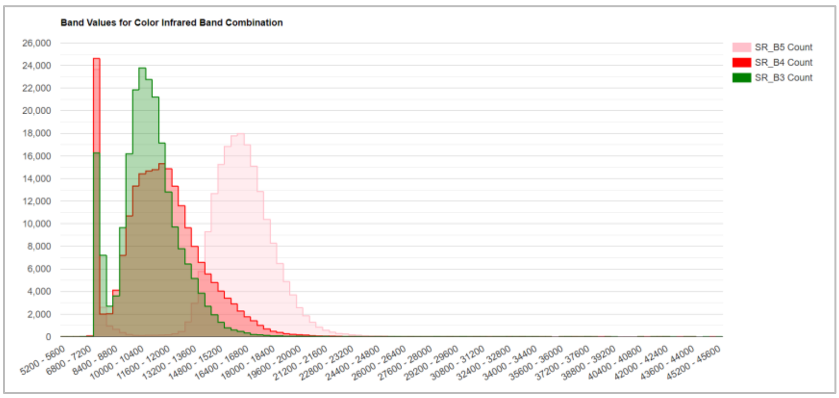
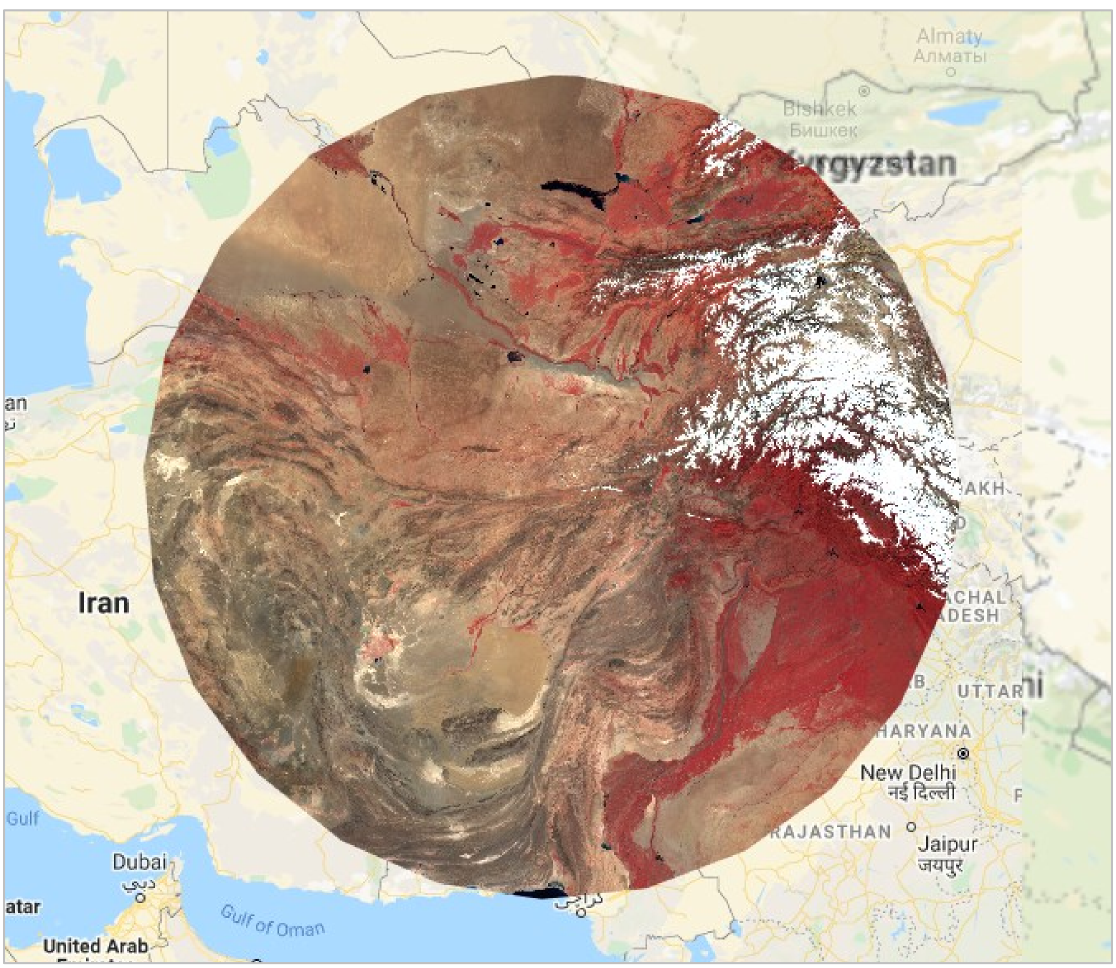
Outlook for Today:

- Result: Create histograms and a few band-combinations for a huge AOI
  - Get to know GEE
  - Get a feeling for cloud processing and why its so powerful
  - See why band combinations are useful
  - Enjoy learning about GEE!

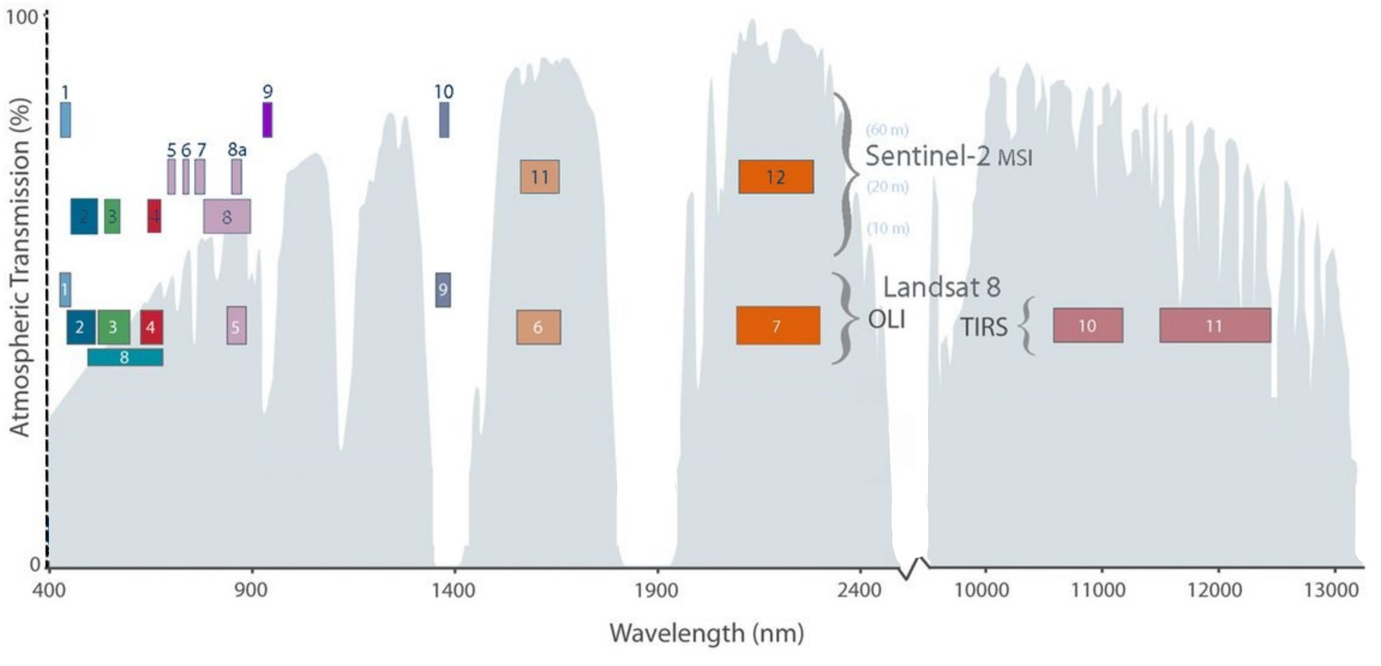




Today's topic: Band combinations

Knowing how to use them can be really useful!
Let's first take a look at what bands are actually captured by some satellite sensors.

Comparison of Landsat 7 and 8 bands with Sentinel-2



Landsat 8 OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor)

Band	Resolution	Wavelength	Description
B1	30 m	0.433 to 0.453 µm	Coastal / Aerosol
B2	30 m	0.450 to 0.515 µm	Visible blue
B3	30 m	0.525 to 0.600 µm	Visible green
B4	30 m	0.630 to 0.680 µm	Visible red
B5	30 m	0.845 to 0.885 µm	Near-infrared
B6	30 m	1.56 to 1.66 µm	Short wavelength infrared
B7	60 m	2.10 to 2.30 µm	Short wavelength infrared
B8	15 m	0.50 to 0.68 µm	Panchromatic
B9	30 m	1.36 to 1.39 µm	Cirrus
B10	100 m	10.3 to 11.3 µm	Long wavelength infrared
B11	100 m	11.5 to 12.5 µm	Long wavelength infrared

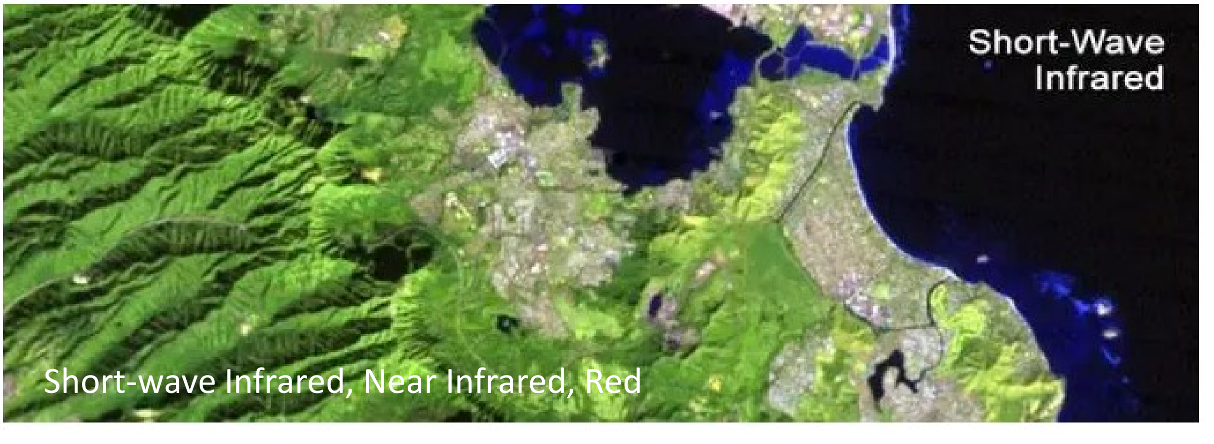
Sentinel-2 MSI (Multispectral Imager)

Band	Resolution	Central Wavelength	Description
B1	60 m	443 nm	Ultra blue (Coastal and Aerosol)
B2	10 m	490 nm	Blue
B3	10 m	560 nm	Green
B4	10 m	665 nm	Red
B5	20 m	705 nm	Visible and Near Infrared (VNIR)
B6	20 m	740 nm	Visible and Near Infrared (VNIR)
B7	20 m	783 nm	Visible and Near Infrared (VNIR)
B8	10 m	842 nm	Visible and Near Infrared (VNIR)
B8a	20 m	865 nm	Visible and Near Infrared (VNIR)
B9	60 m	940 nm	Short Wave Infrared (SWIR)
B10	60 m	1375 nm	Short Wave Infrared (SWIR)
B11	20 m	1610 nm	Short Wave Infrared (SWIR)
B12	20 m	2190 nm	Short Wave Infrared (SWIR)

Some commonly used band combinations:

Natural Color. Used for visual interpretation.

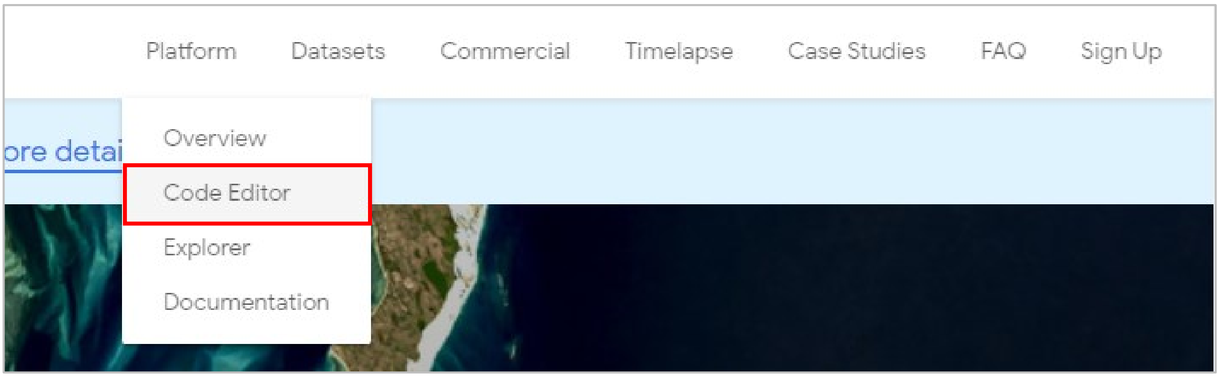
The color infrared composite is used for vegetation analyses. In this case, plants reflect near infrared and green light, while absorbing red. Since they reflect more near infrared than green, plant-covered land appears deep red. Denser plant growth is darker red. This band combination is valuable for analysing plant health.



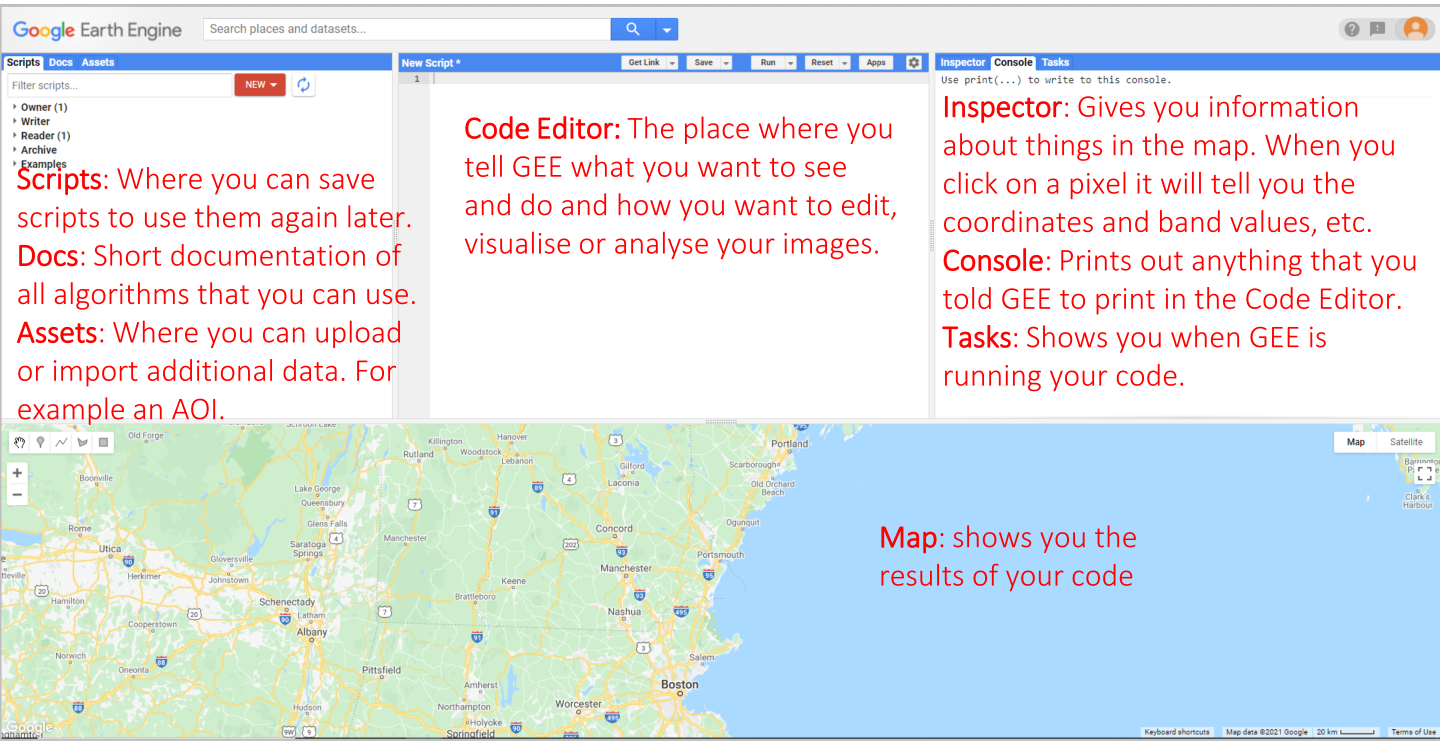
Portrays a landscape in false colors, but in a way that resembles the natural appearance. This combination is often used for geologic analyses (especially in desert landscapes since different surface soils appear in different colors), or agriculture, forestry, or fire management and post-fire analysis.

Getting Started with Google Earth Engine

- For information signing up for GEE, see Blackboard > Information > Software and Data



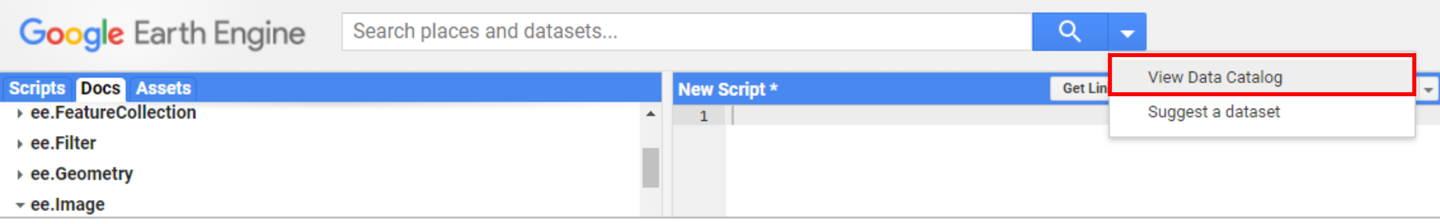
The GEE Interface in plain words:



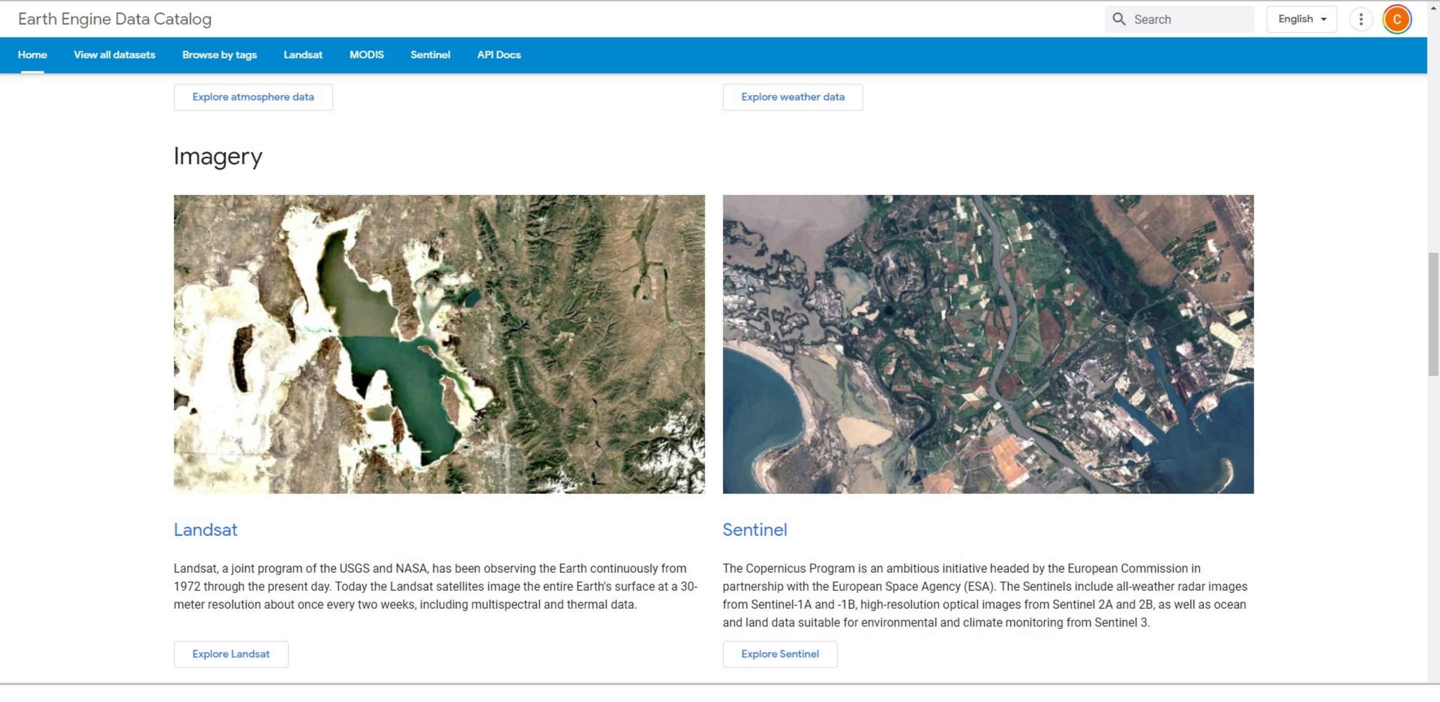
Practical: Image Data and Band Combinations in Google Earth Engine

Lets take a quick look at the Datasets

- Next to the search bar at the top, click on the drop-down menu and click on “View Data Catalog”



- In the new page, scroll down to “Imagery”



- Let’s “Explore Landsat”
  - Here we can see a bunch of information about the Landsat Collections and Missions

Practical: Image Data and Band Combinations in Google Earth Engine

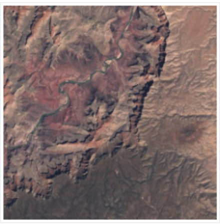
- If we now click on “Landsat 8 Surface Reflectance” in Collection 2, we can inspect some details about this dataset, and we can see relevant information for the code we will write.

Earth Engine Data Catalog

Search

Home | View all datasets | Browse by tags | Landsat | MODIS | Sentinel | API Docs

USGS Landsat 8 Level 2, Collection 2, Tier 1



Dataset Availability

2013-04-11T00:00:00Z - 2021-11-04T00:00:00

Dataset Provider

USGS

Earth Engine Snippet

```
ee.ImageCollection("LANDSAT/LC08/C02/T1_L2")
```

Dataset ID

Tags

cfmask cloud fmask global l8sr landsat lasrc lc08 lst reflectance sr usgs

Description | Bands | Image Properties | Terms of Use

This dataset contains atmospherically corrected surface reflectance and land surface temperature derived from the data produced by the Landsat 8 OLI/TIRS sensors. These images contain 5 visible and near-infrared (VNIR) bands and 2 short-wave infrared (SWIR) bands processed to orthorectified surface reflectance, and one thermal infrared (TIR) band processed to orthorectified surface temperature. They also contain intermediate bands used in calculation of the ST products, as well as QA bands.

Landsat 8 SR products are created with the Land Surface Reflectance Code (LaSRC). All Collection 2 ST products are created with a single-channel algorithm jointly created by the Rochester Institute of Technology (RIT) and National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL).

Strips of collected data are packaged into overlapping "scenes" covering approximately 170km x 183km using a standardized reference grid.

Some assets have only SR data, in which case ST bands are present but empty. For assets with both ST and SR bands, 'PROCESSING_LEVEL' is set to 'L2SP'. For assets with only SR bands, 'PROCESSING_LEVEL' is set to 'L2SR'.

Additional documentation and usage examples.

Data provider notes:

- Data products must contain both optical and thermal data to be successfully processed to surface temperature, as ASTER NDVI is required to temporally adjust the ASTER GED product to the target Landsat scene. Therefore, night time acquisitions cannot be processed to surface temperature.

- When we specify which bands to show, the Band Names are important. The naming convention may change from dataset to dataset, so it’s always good to check!

Description | Bands | Image Properties | Terms of Use

Resolution
30 meters

Bands

Band Names

Name	Units	Min	Max	Scale	Offset	Wavelength	Description
SR_B1		1	65455	2.75e-05	-0.2	0.435-0.451 µm	Band 1 (ultra blue, coastal aerosol) surface reflectance
SR_B2		1	65455	2.75e-05	-0.2	0.452-0.512 µm	Band 2 (blue) surface reflectance
SR_B3		1	65455	2.75e-05	-0.2	0.533-0.590 µm	Band 3 (green) surface reflectance
SR_B4		1	65455	2.75e-05	-0.2	0.636-0.673 µm	Band 4 (red) surface reflectance
SR_B5		1	65455	2.75e-05	-0.2	0.851-0.879 µm	Band 5 (near infrared) surface reflectance
SR_B6		1	65455	2.75e-05	-0.2	1.566-1.651 µm	Band 6 (shortwave infrared 1) surface reflectance
SR_B7		1	65455	2.75e-05	-0.2	2.107-2.294 µm	Band 7 (shortwave infrared 2) surface reflectance
ST_B10	Kelvin	0	65535	0.00341802	149	10.60-11.19 µm	Band 10 surface temperature. If 'PROCESSING_LEVEL' is set to 'L2SR', this band is fully masked out.

- The same goes for the Image Properties. Often we will want to use the image properties to filter a dataset (for example for cloud cover), so we need to make sure we are using the correct image property name.

Description | Bands | Image Properties | Terms of Use

Image Properties

Name (Property Names)	Type	Description
ALGORITHM_SOURCE_SURFACE_REFLECTANCE	STRING	Name and version of the surface reflectance algorithm.
ALGORITHM_SOURCE_SURFACE_TEMPERATURE	STRING	Name and version of the surface temperature algorithm.
CLOUD_COVER	DOUBLE	Percentage cloud cover (0-100), -1 = not calculated.
CLOUD_COVER_LAND	DOUBLE	Percentage cloud cover over land (0-100), -1 = not calculated.
COLLECTION_CATEGORY	STRING	Scene collection category, "T1" or "T2".
DATA_SOURCE_AIR_TEMPERATURE	STRING	Air temperature data source.
DATA_SOURCE_ELEVATION	STRING	Elevation data source.
DATA_SOURCE_OZONE	STRING	Ozone data source.
DATA_SOURCE_PRESSURE	STRING	Pressure data source.
DATA_SOURCE_REANALYSIS	STRING	Reanalysis data source.
DATA_SOURCE_TIRS_STRAY_LIGHT_CORRECTION	STRING	TIRS stray light correction data source.
DATA_SOURCE_WATER_VAPOR	STRING	Water vapor data source.
DATE_PRODUCT_GENERATED	DOUBLE	Timestamp of the date when the product was generated.

- With this information we can already start to create our own code.
  - Switch back to the Code Editor Tab.

1. Create a Point of Interest anywhere in the world

- Use the Geometry Drawing Tools in the map to draw a point
- Don't go too close to the oceans

- As soon as you finish drawing it, notice the geometry appear in the Code Editor
- Rename it to 'poi' (simply click on the word 'geometry' to edit it)

```
Imports (1 entry)
  var poi: Point (39.60, 8.92)
```

- Now we can create a very large AOI, by adding a buffer of 1 million meters (1000 km)
- Add this code at the top of your script

```
// 1. create area of interest around point, with a radius of 1 million meters
var aoi = poi.buffer(1000000);
```

- With a radius of 1 million meters, we now have an AOI of about 3.1 million km^2

2. Create Variables for Start and End Dates for the Search

The // indicate a comment.
Its best practice to use comments to keep track of what your code is doing

```
// 2. Set start and end date range
var start = ee.Date('2019-01-01');
var end = ee.Date('2021-01-01');
```

Create variables to contain start and end dates

ee.Date is a built-in function that can read and understand dates

The date: yyyy-mm-dd

3. Create a Variable for our ImageCollection and filter it to find fitting images

ee.ImageCollection is a built-in function that calls image collections

Remember the Dataset ID we saw in the Landsat Image Collection? This is where we need it

```
// 3. Call and filter an image collection
var myImageCollection = ee.ImageCollection('LANDSAT/LC08/C02/T1_L2')
.filterBounds(aoi)
.filterDate(start, end)
.filter('CLOUD_COVER < 15');
```

The filtering function excludes any images that don't fit the criteria

less than 15 %

Remember the Image Properties we saw in the Landsat Image Collection? This is where we need it

filterBounds means we are filtering by our AOI (use the name that you gave your AOI here)

filterDate means we are filtering by our start and end dates as the time period to search

4. Print out some Information

Create a variable that contains the size (= count) of images that are now in our "myImageCollection"

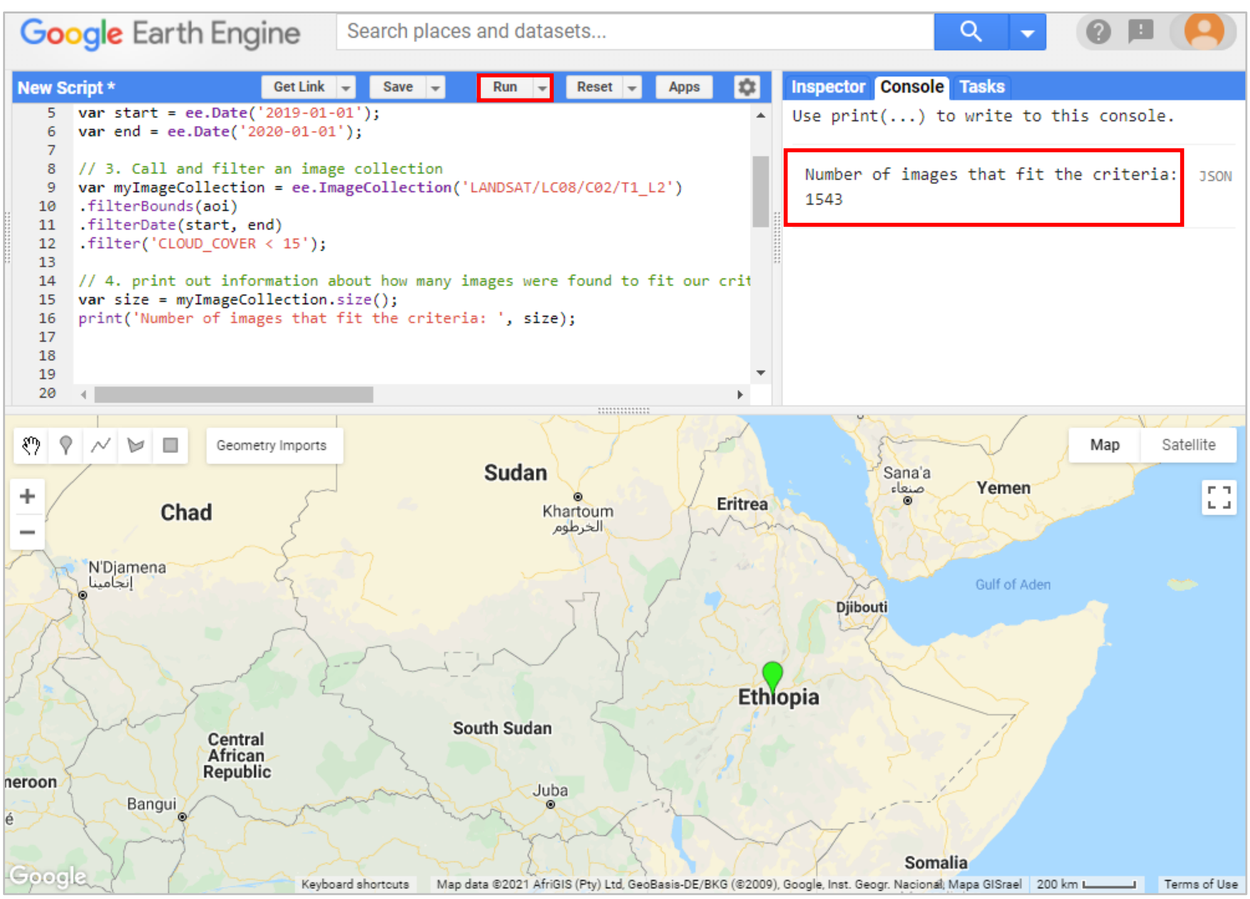
```
// 4. print out information about how many images were found to fit our criteria
var size = myImageCollection.size();
print('Number of images that fit the criteria: ', size);
```

The print function will print something to the console

Descriptive text to be printed to the console

Print out the value of the variable "size"

- Now we can click "Run" to see if everything is going well so far. If all is well, we will see a result in the Console.



5. Create Median Collection

- The .median() function calculates the median of all values at each pixel across the stack of all matching bands.

```
// 5. Create collection of median pixel values of all valid images
var median = myImageCollection.median();
```

6. Define Band Combinations

- We can prepare the selection of bands by defining them in a variable

```
// 6. Define Band Combinations
var bandsRGB = ['SR_B4', 'SR_B3', 'SR_B2'];
var bandsNIR = ['SR_B5', 'SR_B4', 'SR_B3'];
var bandsSWIR = ['SR_B7', 'SR_B6', 'SR_B4'];
```

← Here we use the band names that we saw in the data catalog for Landsat 8

- Now we can test to see how the visualisation looks without any stretching

```
// 7. Test non-streched visualisation
Map.addLayer(median.clip(aoi), {bands: bandsRGB}, 'Not Stretched RGB');
```

↑ Generic function to add a layer to the map (`Map.addLayer`)

↑ Layer to add (`median.clip(aoi)`)

↑ Layer Visualisation Parameters (`{bands: bandsRGB}`)

↑ Layer Name (`'Not Stretched RGB'`)

- "Run"
  - Looks a bit dark, doesn't it?

8. Create Histograms to View Min and Max Values

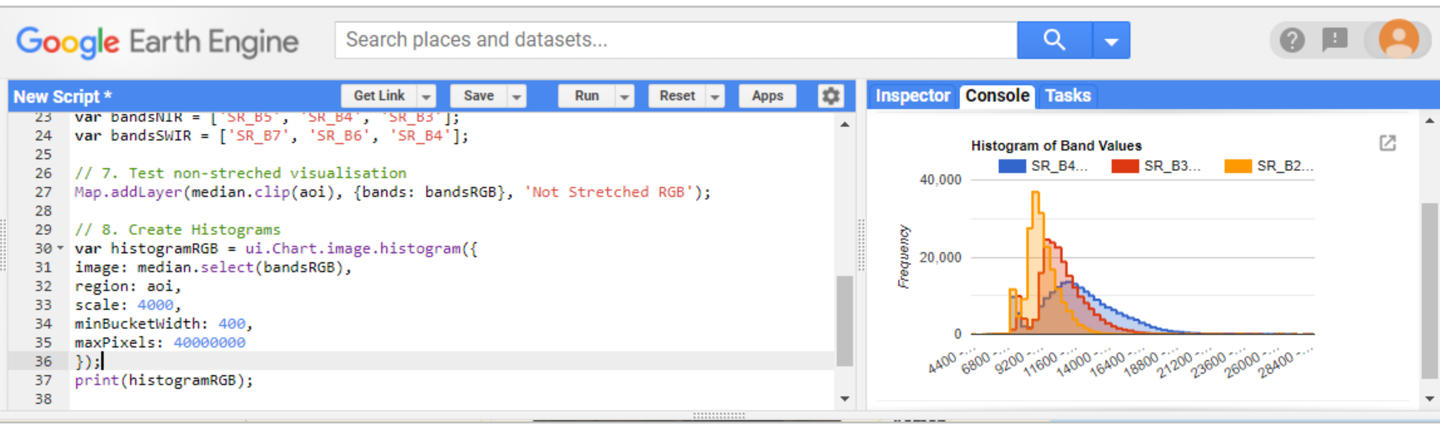
- With the help of the histogram we can decide where to set the Min and Max values for our visualisations

```
// 8. Create Histogram

var histogramRGB = ui.Chart.image.histogram({
  image: median.select(bandsRGB),
  region: aoi,
  scale: 4000,
  minBucketWidth: 400,
  maxPixels: 40000000
});
print(histogramRGB);
```

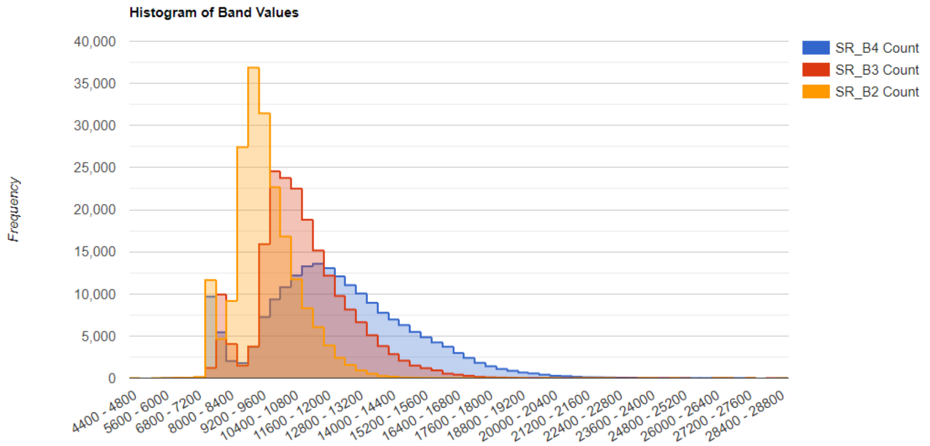
Generic function to create a histogram

Print the histogram

- “Run”



- You can click on the “Open in New Window” button to see the histogram in full size.



9. Set Visualisation for Min and Max Values and add the Stretched Results to the Map

- With the help of the histogram we can now see which min and max values to define

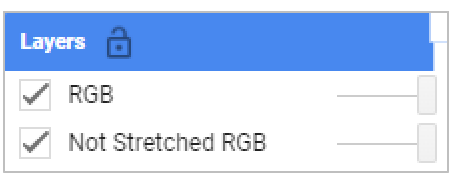
```
// 9. Add images to the map
Map.addLayer(median.clip(aoi), {bands: bandsRGB, min: 7200, max: 20800}, 'RGB');
```

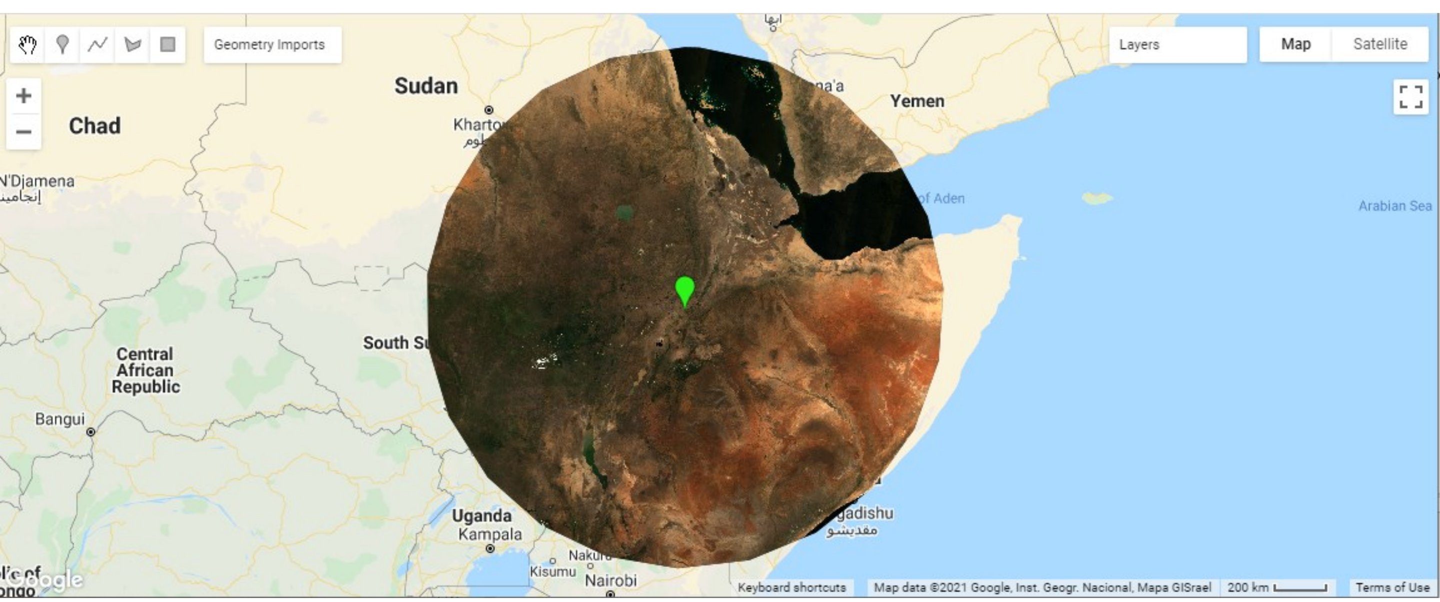
Image

Layer Visualisation

Layer Name

- Click “Run”
- Use the Layers Menu in the Map to turn your layers on and off to see the others





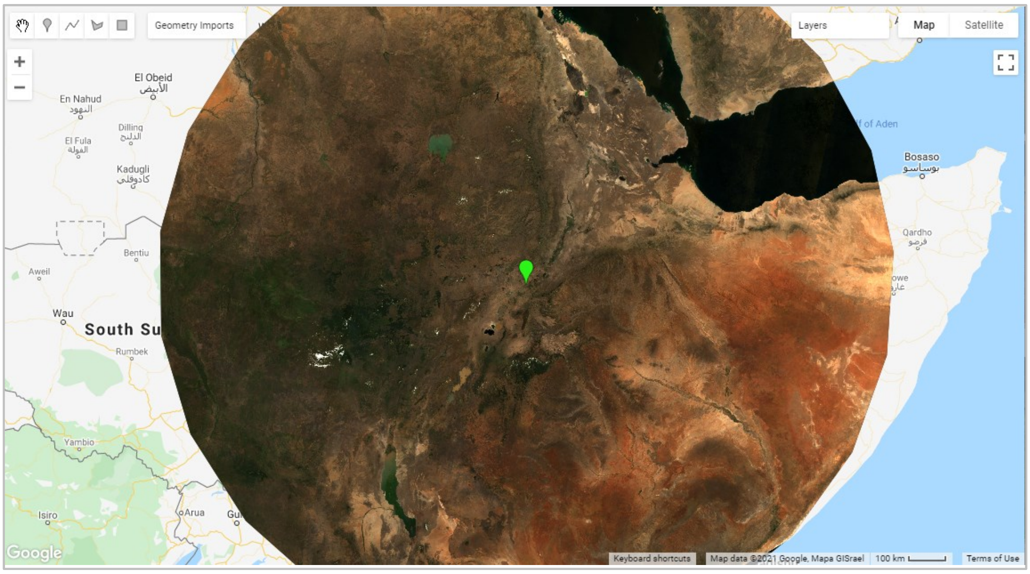
10. Do the same for other band combinations

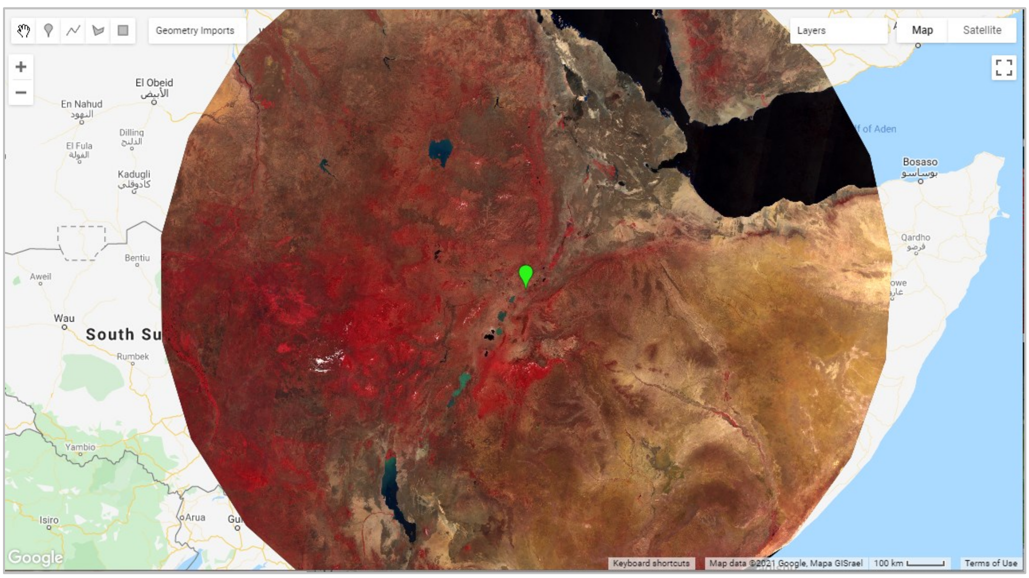
- Go back to 8. and add two more histograms (you can copy and paste the first one) for these new band combinations:

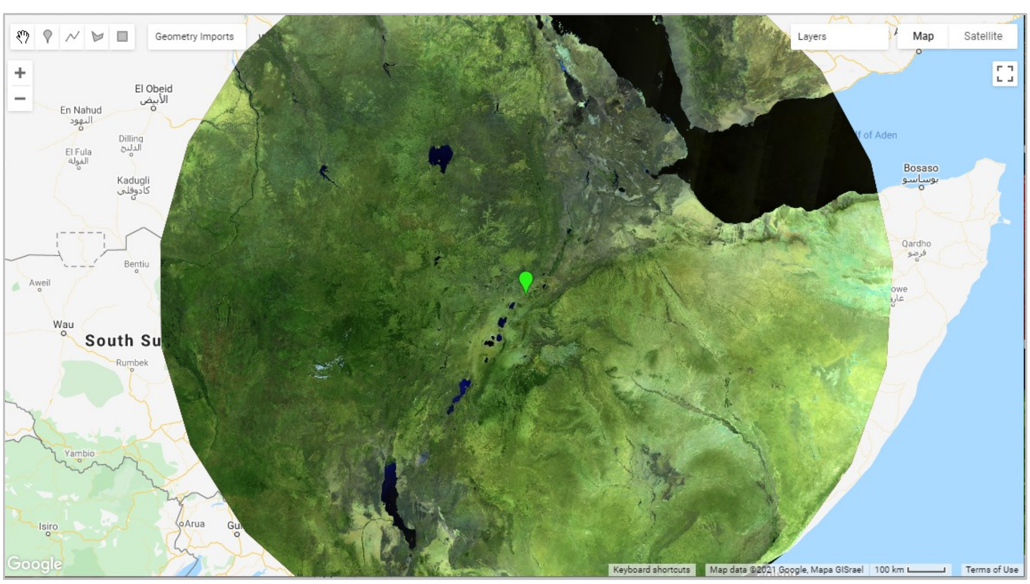
```
// 8. Create Histograms

var histogramRGB = ui.Chart.image.histogram({
image: median.select(bandsRGB),
region: aoi,
scale: 4000,
minBucketWidth: 400,
maxPixels: 40000000
});
print(histogramRGB);

var histogramNIR = ui.Chart.image.histogram({
image: median.select(bandsNIR),
region: aoi,
scale: 4000,
minBucketWidth: 400,
maxPixels: 40000000
});
print(histogramNIR);

var histogramSWIR = ui.Chart.image.histogram({
image: median.select(bandsSWIR),
region: aoi,
scale: 4000,
minBucketWidth: 400,
maxPixels: 40000000
});
print(histogramSWIR);
```

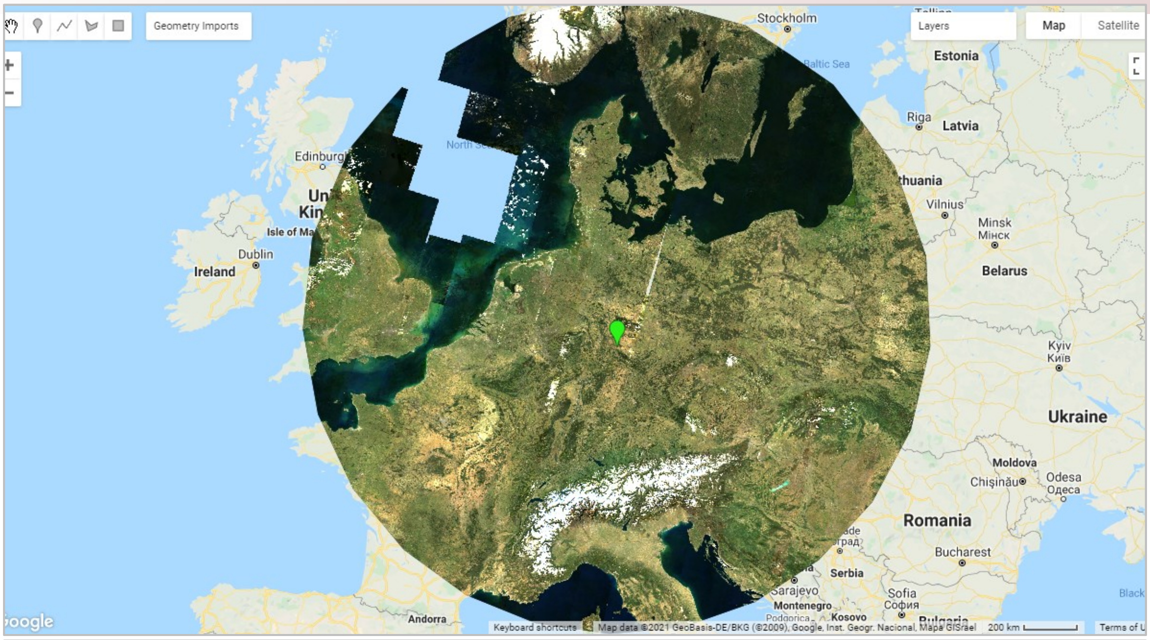
- "Run"
- Use the histograms to set new visualisations for the NIR and SWIR visualisations

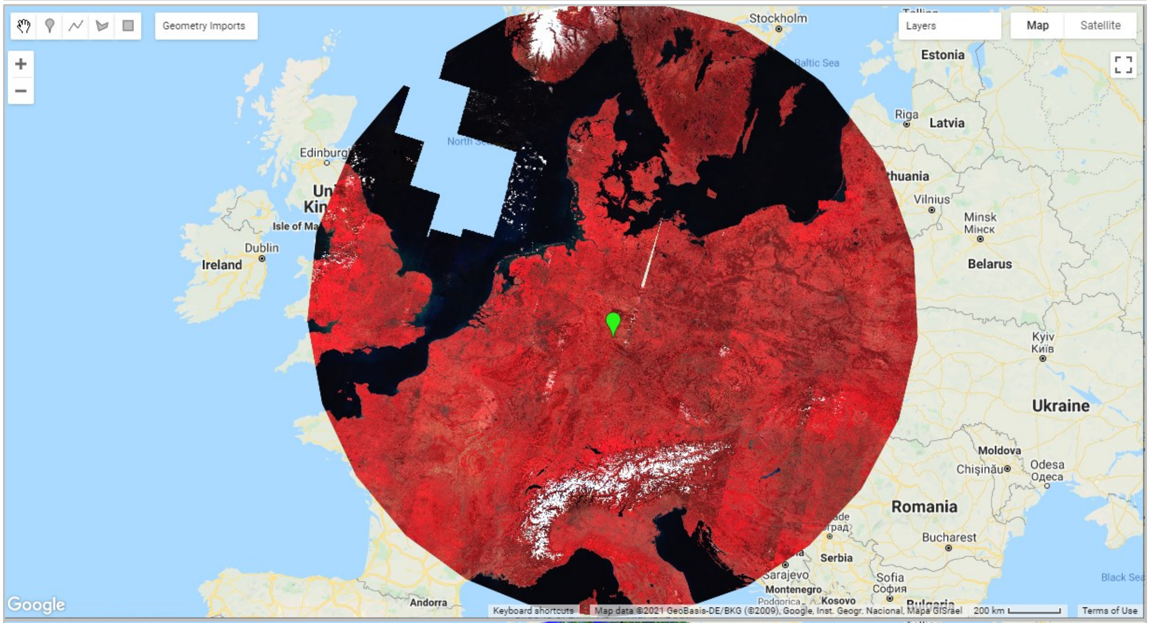
```
// 9. Add images to the map
Map.addLayer(bestImage, {bands: bandsRGB, min: 7200, max: 19200}, 'RGB');
Map.addLayer(bestImage, {bands: bandsNIR, min: 7200, max: 24000}, 'NIR');
Map.addLayer(bestImage, {bands: bandsSWIR, min: 7200, max: 27600}, 'SWIR');
```

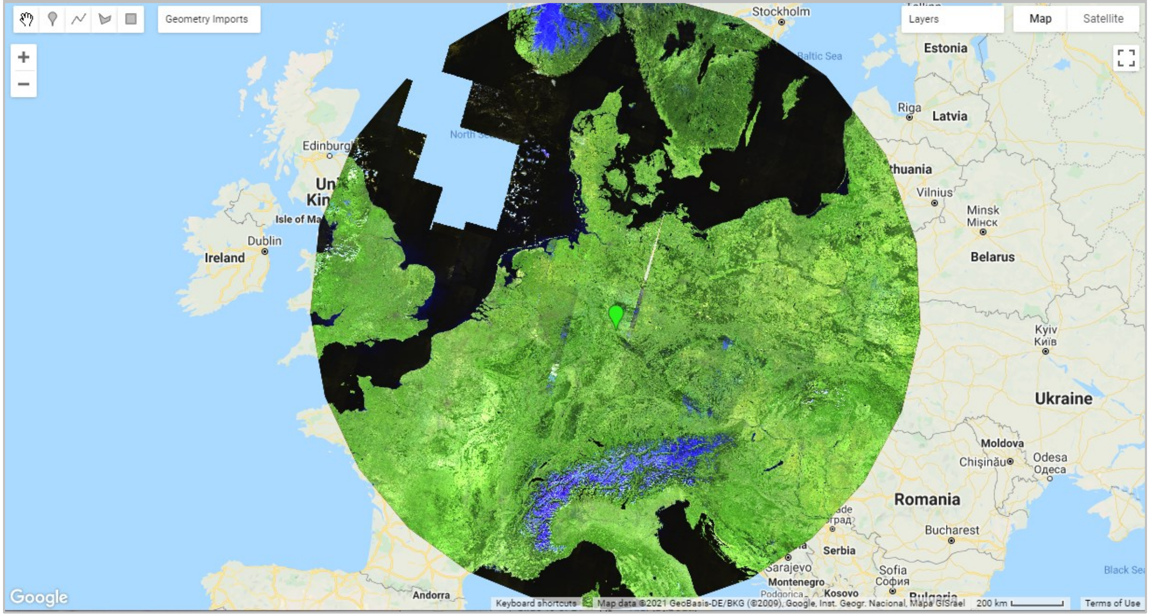

Geometry Imports
Layers
Map
Satellite
El Obeid
En Nahud
Dilling
El Fula
Kadugli
Bentiu
Aweil
Wau
South Su
Rumbek
Yambio
Isiro
Arua
Bosaso
Qardho
Google
Keyboard shortcuts
Map data ©2021 Google, Mapa GISrael
100 km
Terms of Use


Geometry Imports
Layers
Map
Satellite
El Obeid
En Nahud
Dilling
El Fula
Kadugli
Bentiu
Aweil
Wau
South Su
Rumbek
Yambio
Isiro
Arua
Bosaso
Qardho
Google
Keyboard shortcuts
Map data ©2021 Google, Mapa GISrael
100 km
Terms of Use


Geometry Imports
Layers
Map
Satellite
El Obeid
En Nahud
Dilling
El Fula
Kadugli
Bentiu
Aweil
Wau
South Su
Rumbek
Yambio
Isiro
Arua
Bosaso
Qardho
Google
Keyboard shortcuts
Map data ©2021 Google, Mapa GISrael
100 km
Terms of Use

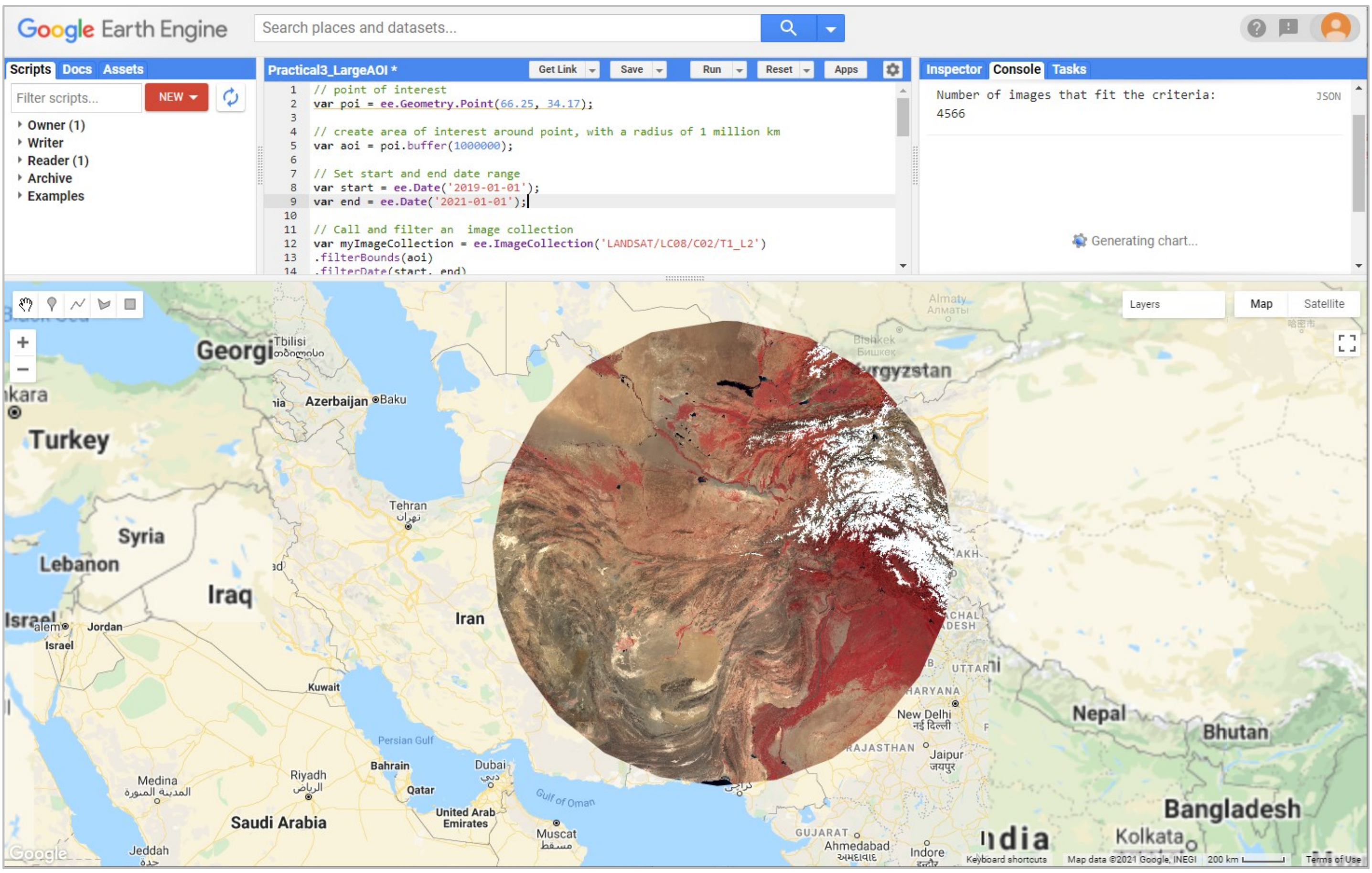

Geometry Imports
Layers
Map
Satellite
Stockholm
Estonia
Riga
Latvia
Edinburgh
Isle of Man
Dublin
Ireland
Vilnius
Minsk
Мінск
Belarus
Kyiv
Київ
Ukraine
Moldova
Chişinău
Odesa
Одеса
Romania
Bucharest
Serbia
Sarajevo
Montenegro
Sofia
София
Kosovo
Andorra
Keyboard shortcuts
Map data ©2021 GeoBasis-DE/BKG (©2009), Google, Inst. Geogr. Nacional, Mapa GISrael
200 km


Geometry Imports
Layers
Map
Satellite
Stockholm
Estonia
Riga
Latvia
Edinburgh
Isle of Man
Dublin
Ireland
Vilnius
Minsk
Мінск
Belarus
Kyiv
Київ
Ukraine
Moldova
Chişinău
Odesa
Одеса
Romania
Bucharest
Serbia
Sarajevo
Montenegro
Sofia
София
Kosovo
Andorra
Google
Keyboard shortcuts
Map data ©2021 GeoBasis-DE/BKG (©2009), Google, Inst. Geogr. Nacional, Mapa GISrael
200 km
Terms of Use

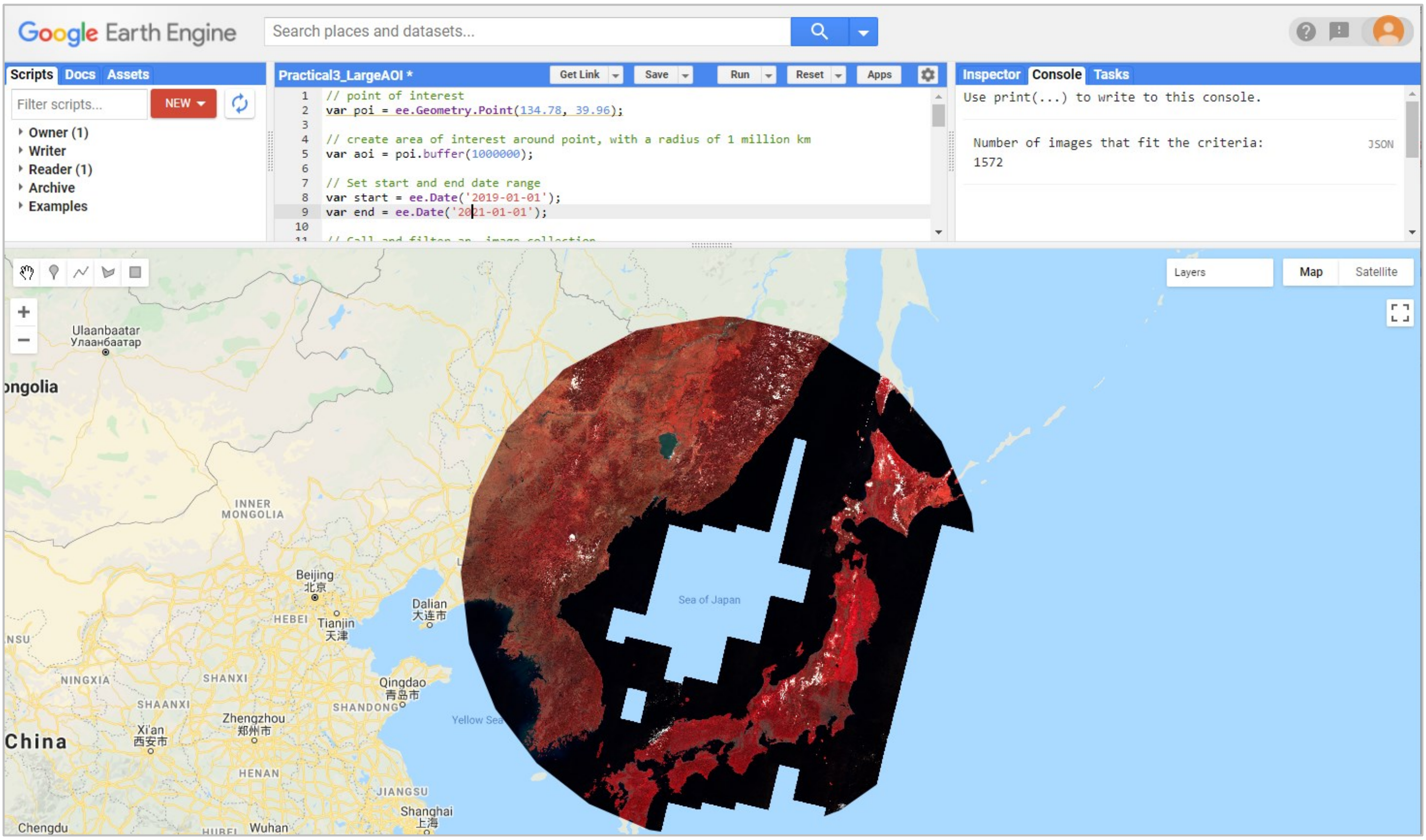

Geometry Imports
Layers
Map
Satellite
Stockholm
Estonia
Riga
Latvia
Edinburgh
Isle of Man
Dublin
Ireland
Vilnius
Minsk
Мінск
Belarus
Kyiv
Київ
Ukraine
Moldova
Chişinău
Odesa
Одеса
Romania
Bucharest
Serbia
Sarajevo
Montenegro
Sofia
София
Kosovo
Andorra
Google
Keyboard shortcuts
Map data ©2021 GeoBasis-DE/BKG (©2009), Google, Inst. Geogr. Nacional, Mapa GISrael
200 km
Terms of Use

- You can easily change this code for anywhere else in the world by **simply changing the point coordinates** at the very top and clicking “run” again!!
  - You may need to adjust the min and max values in the visualisation based on the histogram

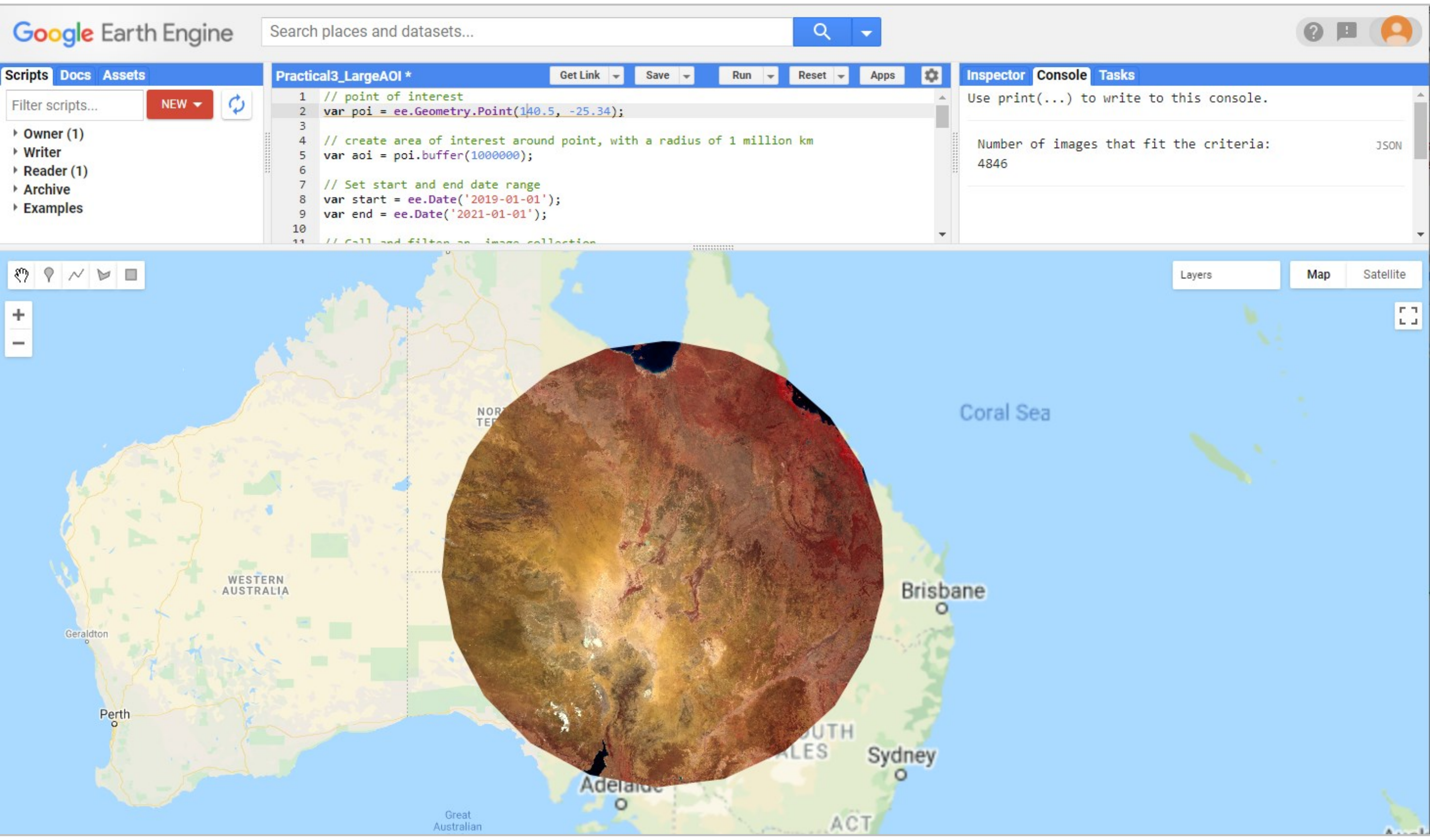
Here: my “poi” is in the middle of Afghanistan

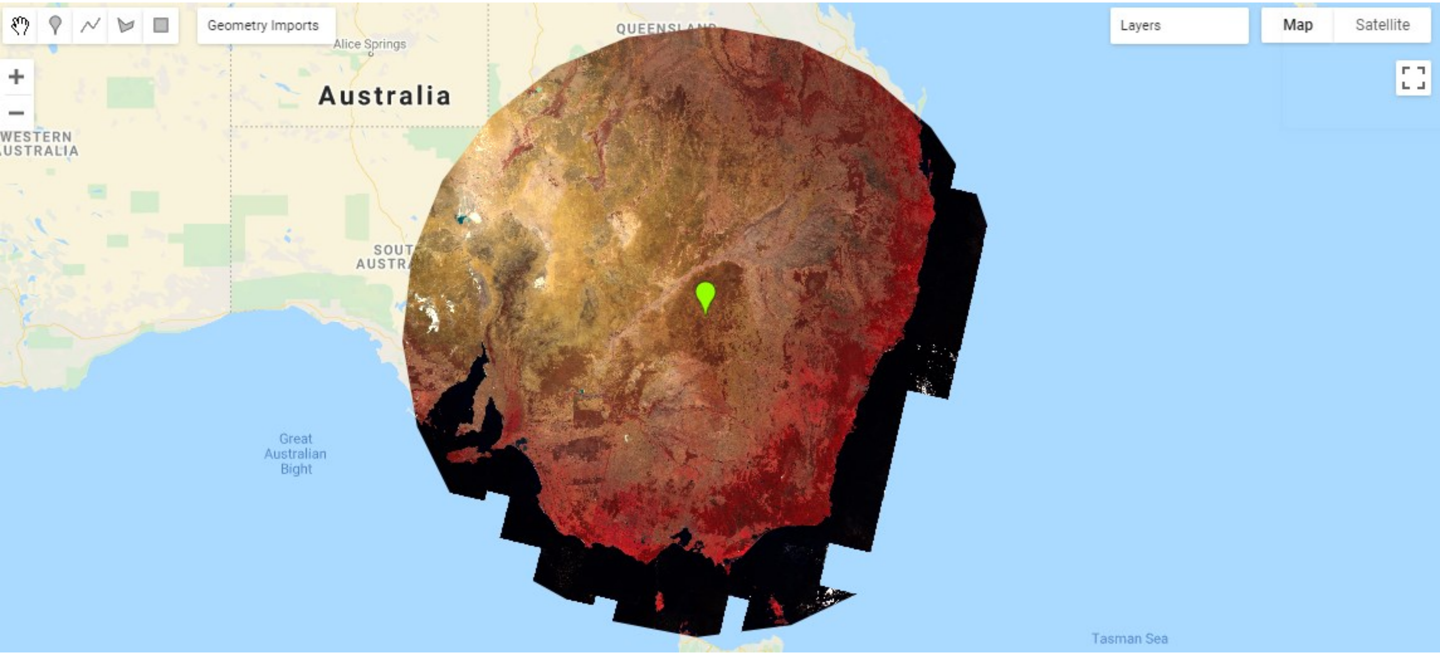


Here: my “poi” is in the middle of Japan, North and South Korea!



Here: my “poi” is in the middle of Australia!





Zoom in South of Baghdad

Complete Script

- Set an geometry Point called "poi" with the geometry tools!
- Adjust the min and max values for the layers (use the histograms to decide!)

```
Imports (1 entry)
▸ var poi: Point (39.41, 8.63)
```

```
// 1. create area of interest around point, with a radius of 1 million meters
var aoi = poi.buffer(1000000);

// 2. set start and end dates
var start = ee.Date('2019-01-01');
var end = ee.Date('2020-01-01');

// 3. Call and filter an image collection
var myImageCollection = ee.ImageCollection('LANDSAT/LC08/C02/T1_L2')
.filterBounds(aoi)
.filterDate(start, end)
.filter('CLOUD_COVER < 15');

// 4. print out information about how many images were found to fit our criteria
var size = myImageCollection.size();
print('Number of images that fit the criteria: ', size);

// 5. Create collection of median pixel values of all valid images
var median = myImageCollection.median();

// 6. Define Band Combinations
var bandsRGB = ['SR_B4', 'SR_B3', 'SR_B2'];
var bandsNIR = ['SR_B5', 'SR_B4', 'SR_B3'];
var bandsSWIR = ['SR_B7', 'SR_B6', 'SR_B4'];

// 7. Test non-streched visualisation
Map.addLayer(median.clip(aoi), {bands: bandsRGB}, 'Not Stretched RGB');

// 8. Create Histograms
var histogramRGB = ui.Chart.image.histogram({
image: median.select(bandsRGB),
region: aoi,
scale: 4000,
minBucketWidth: 400,
maxPixels: 40000000
});
print(histogramRGB);

var histogramNIR = ui.Chart.image.histogram({
image: median.select(bandsNIR),
region: aoi,
scale: 4000,
minBucketWidth: 400,
maxPixels: 40000000
});
print(histogramNIR);

var histogramSWIR = ui.Chart.image.histogram({
image: median.select(bandsSWIR),
region: aoi,
scale: 4000,
minBucketWidth: 400,
maxPixels: 40000000
});
print(histogramSWIR);

// 9. Add images to the map
Map.addLayer(median.clip(aoi), {bands: bandsRGB, min: 7200, max: 20800}, 'RGB');
Map.addLayer(median.clip(aoi), {bands: bandsNIR, min: 7200, max: 24000}, 'NIR');
Map.addLayer(median.clip(aoi), {bands: bandsSWIR, min: 7200, max: 27600}, 'SWIR');
```