# Assessing Urban Heat Island Effect - 2019

Lunel - Paris - France

# WHAT ARE URBAN HEAT ISLANDS?

- The difference in temperature between urban and suburban regions and their rural environments.
- An urban heat island (UHI) is a city or metropolitan area that is much warmer than its surrounding rural areas.
- This is mostly attributed to urban areas consisting man-made surfaces such as paving and building material, causing a warming effect.
- UHI is affected by several factors such as surrounding ecological contact, size of the city (area and population), shape of the city, and the spatial pattern (physical concept) of the city.

# Urban Heat Island Concept

- In summary, contrary to rural landscapes, cities are mostly paved or built up, so no vegetation or moisture can absorb heat and cool down the land; asphalt, concrete and surfaces simply absorb the energy of the sun during the day and release it again at night. During the day, impervious surfaces in urban areas absorb strongly heat energy (i.e., warm up more) than adjoining outskirts, causing a somewhat bubble of warm air over the urban areas. This effect is more noticeable at night than in the morning hours/afternoon hours.

# Urban Heat Island (UHI) and Global Warming

UHI is different from global warming!

Urban areas is said to be a major factor responsible for Global warming.

↔

Global warming has increased the impacts of urban heat felt in cities , especially during the spring and summer periods.

# Impacts of UHI

- UHI's have negative impacts on the health. 
- contributes to global warming. 

- Issues of social inequality. 

- Reduced potential for tourism, outdoor exercise etc. 

# Study Area - Lunel

- Lunel is a commune located in the Herault department of Southern France on the outskirts of the city of Montpellier

- The commune has a population of around 26,000

- It is located around  10 km from the Mediterranean Sea

- The town centre is dominated by traditional housing consisting of multi-story, stone tenement buildings with minimal green-space. The outskirts consist of a mix of modern-build villas, apartment blocks and industrial sites.

- Green-space generally increases with distance from the town centre

# Study Area - Paris

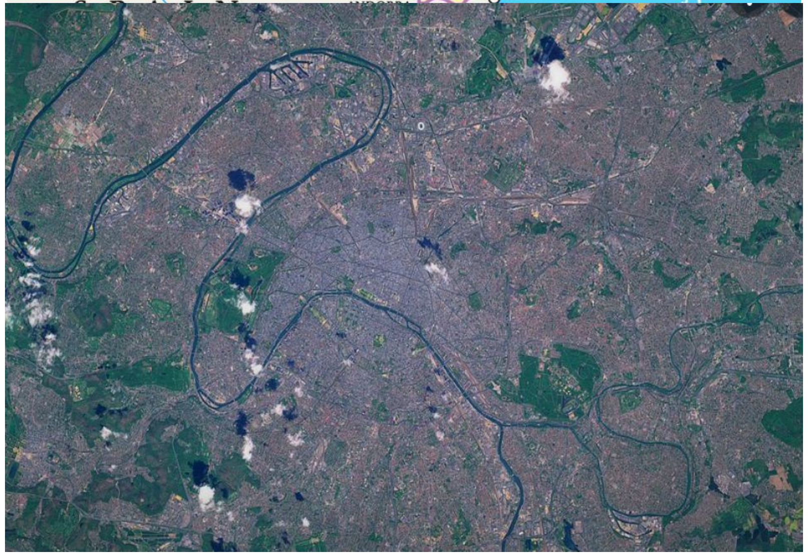
- Population of over 2 million people with a greater urban area of over 11 million

- Located in Northern France, over 100 km from the ocean

- One of the most densely populated cities in Europe

- The city architecture is mixed with areas of historic residential buildings, modern apartment blocks, large urban parks etc. The majority of buildings are multi-storey

- Numerous large planned greenspace areas

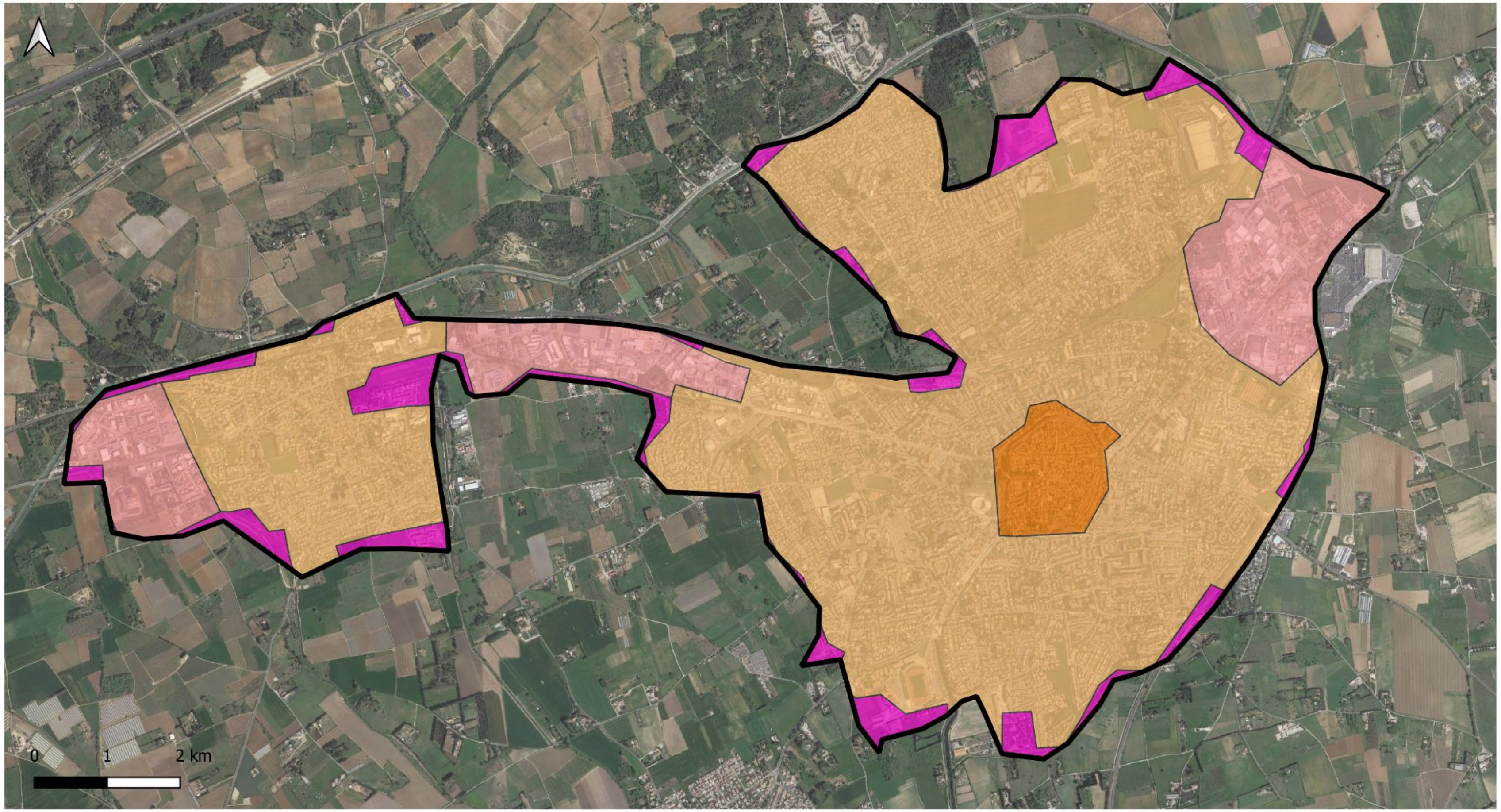



# Study Area

## PARIS


## LUNEL

# Lunel, France - Corine Land Cover 2018




Lunel

**CLC - 2018**

Continuous urban fabric

Discontinuous urban fabric

Industrial or commercial units

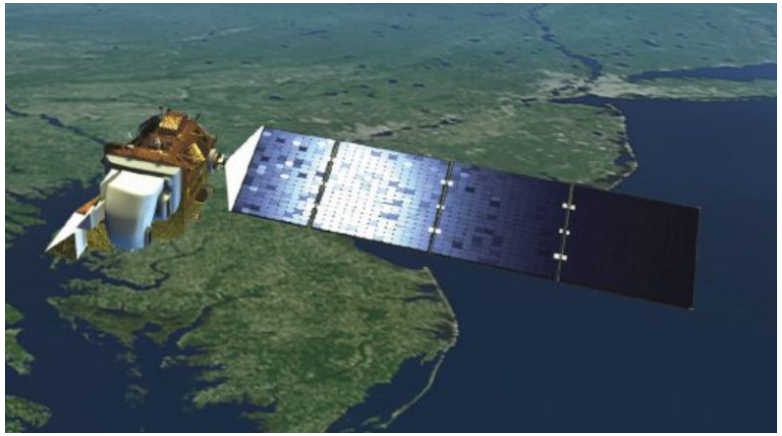
Non classified

EPSG:3035 - ETRS89-extended / LAEA Europe - Projected
Rerecences: Corine Land Cover - COPERNICUS, 2018 / data.gov.fr

# Paris, France - Corine Land Cover 2018

# EO Technique to investigate UHI

- Urban Heat Island are majorly mapped and investigated using Earth Observation technique majorly Land Surface Temperature data from Landsat | Sentinel 3| MODIS or Impervious surface data from satellite imagery or both.

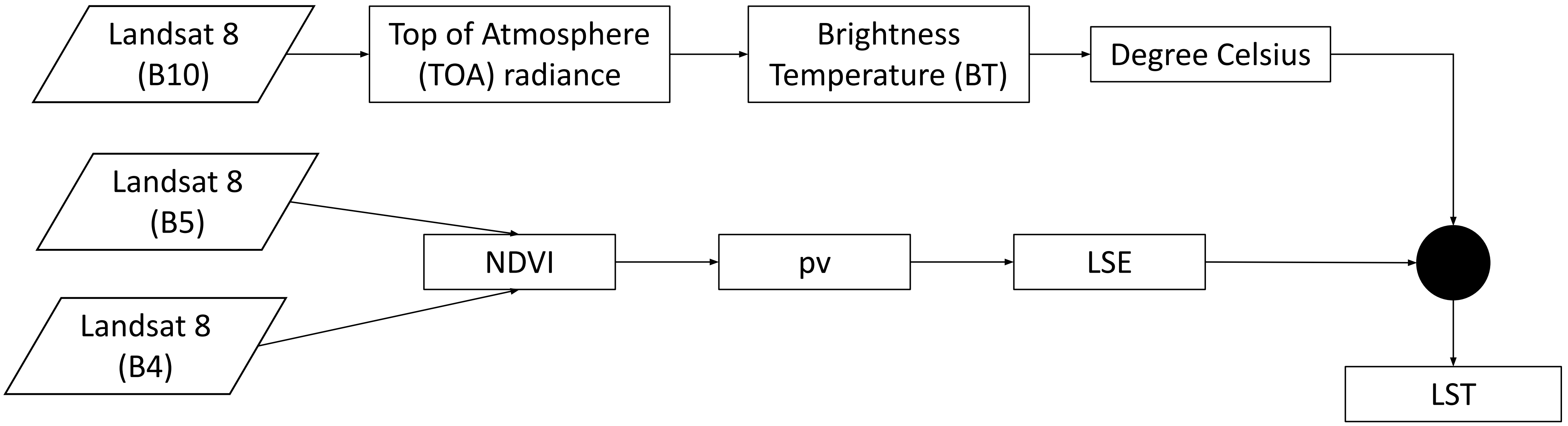


# Objectives

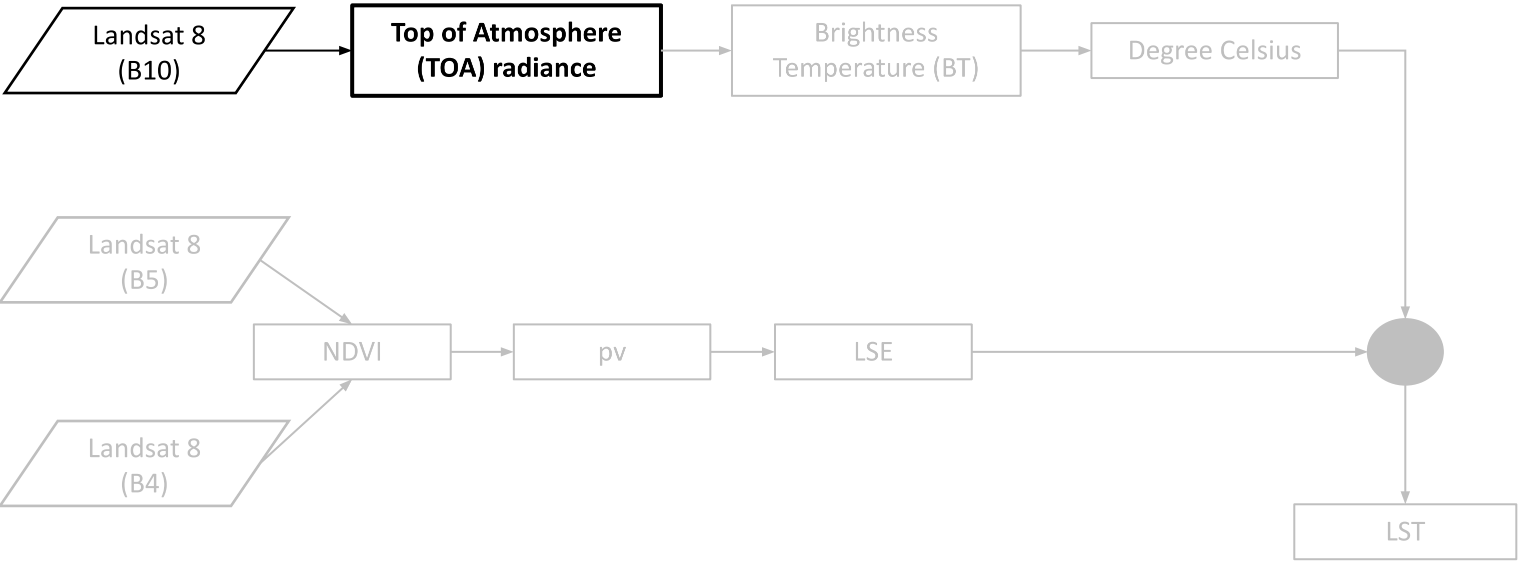
- Compare LST data in Lunel and Paris (Landsat 8);
- ARCGIS PRO:  Visualizing the LST and identifying UHI and cold spots;
- Google Earth Engine: Plotting time series LST;
- Terrascope

# ARCGIS PRO

# Methodology



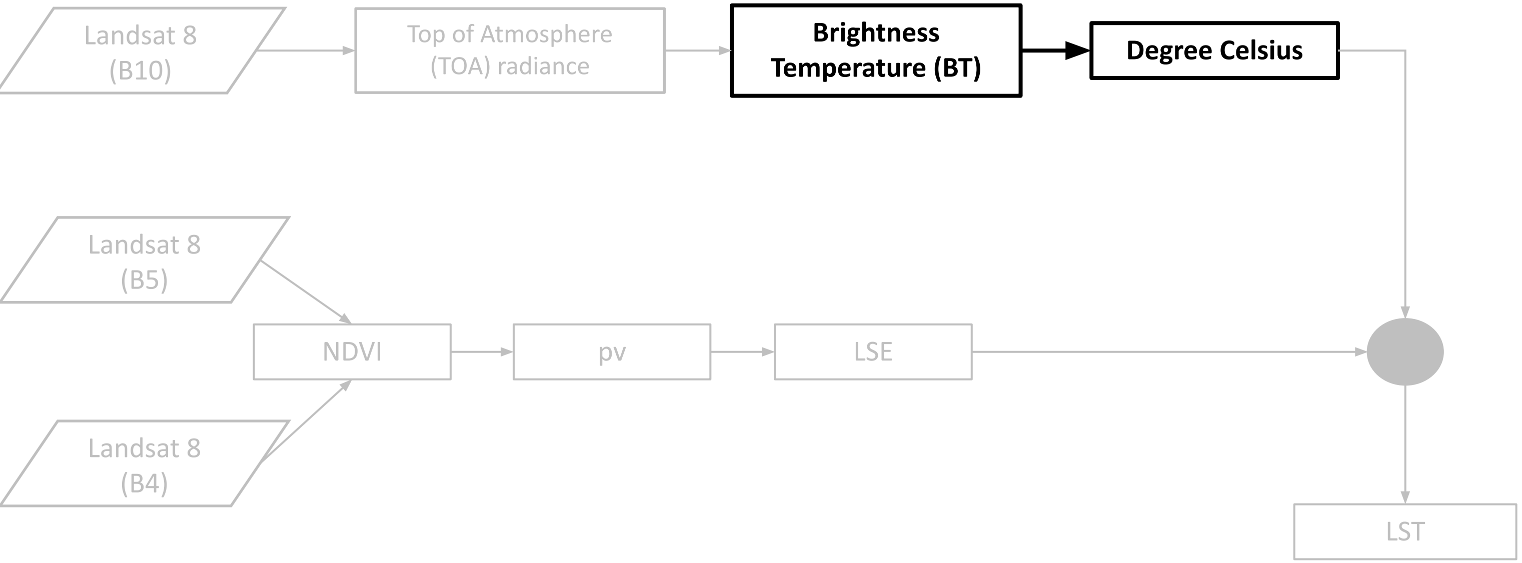
# Conversion to Top of Atmosphere (TOA) radiance




- The SWIR (Band 10) is first converted from DN values to the TOA spectral radiance (reflectance) using the radiometric rescaling coefficient substituted in the formular below:

$$TOA = M_L Q_{cal} + A_L$$

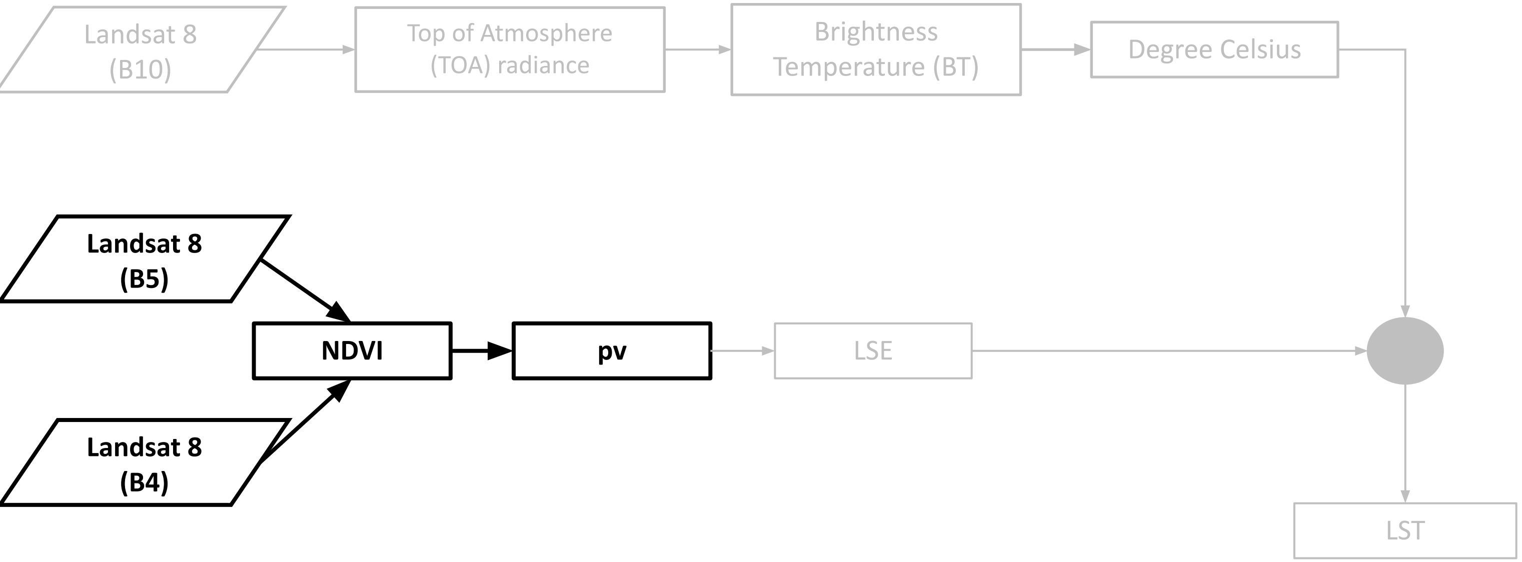
# Conversion to Brightness Temperature




- The SWIR/TIRS (Band 10) is then converted from spectral reflectance to TOA brightness temperature using the thermal constant substituted in the formular:

$$BT = \frac{k_2}{\ln\left(\frac{k_1}{L_1}+1\right)} - 273.15$$

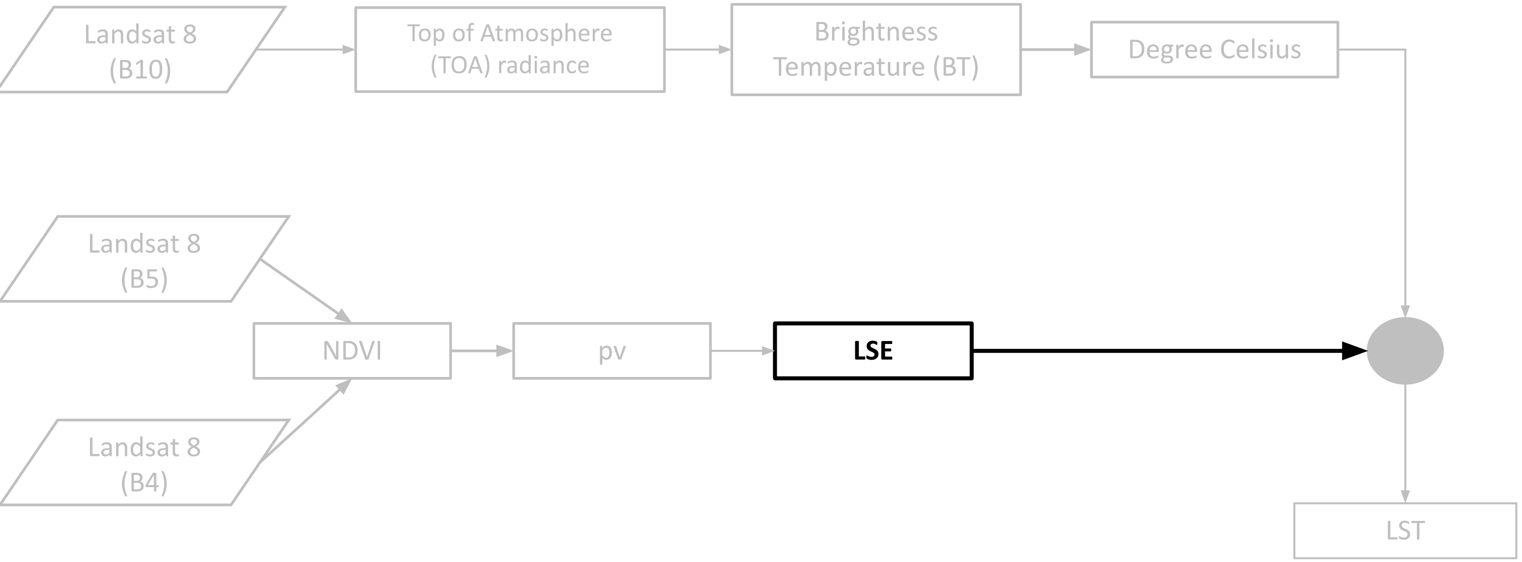
# Computing NDVI and Proportion of Vegetation




$$NDVI = \frac{NIR\ (B5) - R\ (B4)}{NIR\ (B5) + R\ (B4)}$$

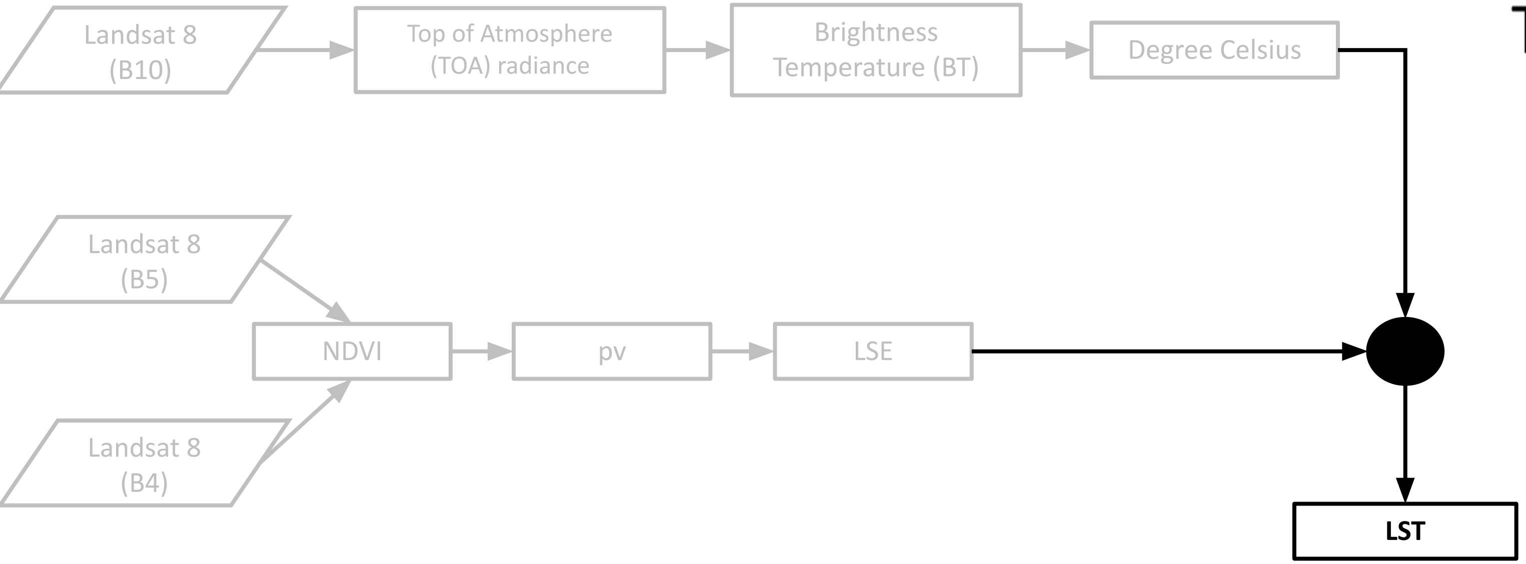
$$pv = \left( \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}} \right)^2$$

# Land Surface Emissivity



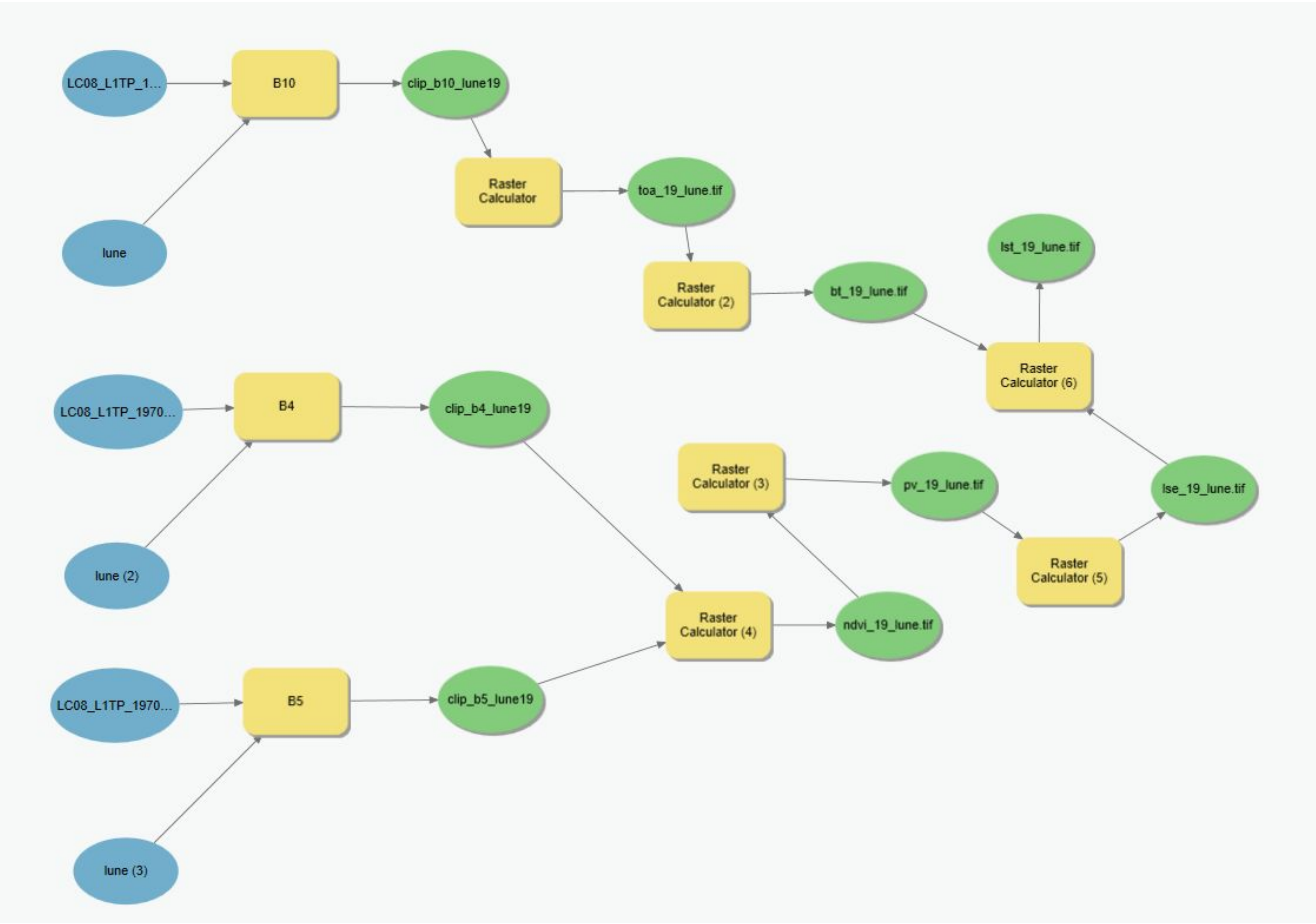

$$LSE(e) = 0.004 * pv + 0.986$$

# Land Surface Temperature

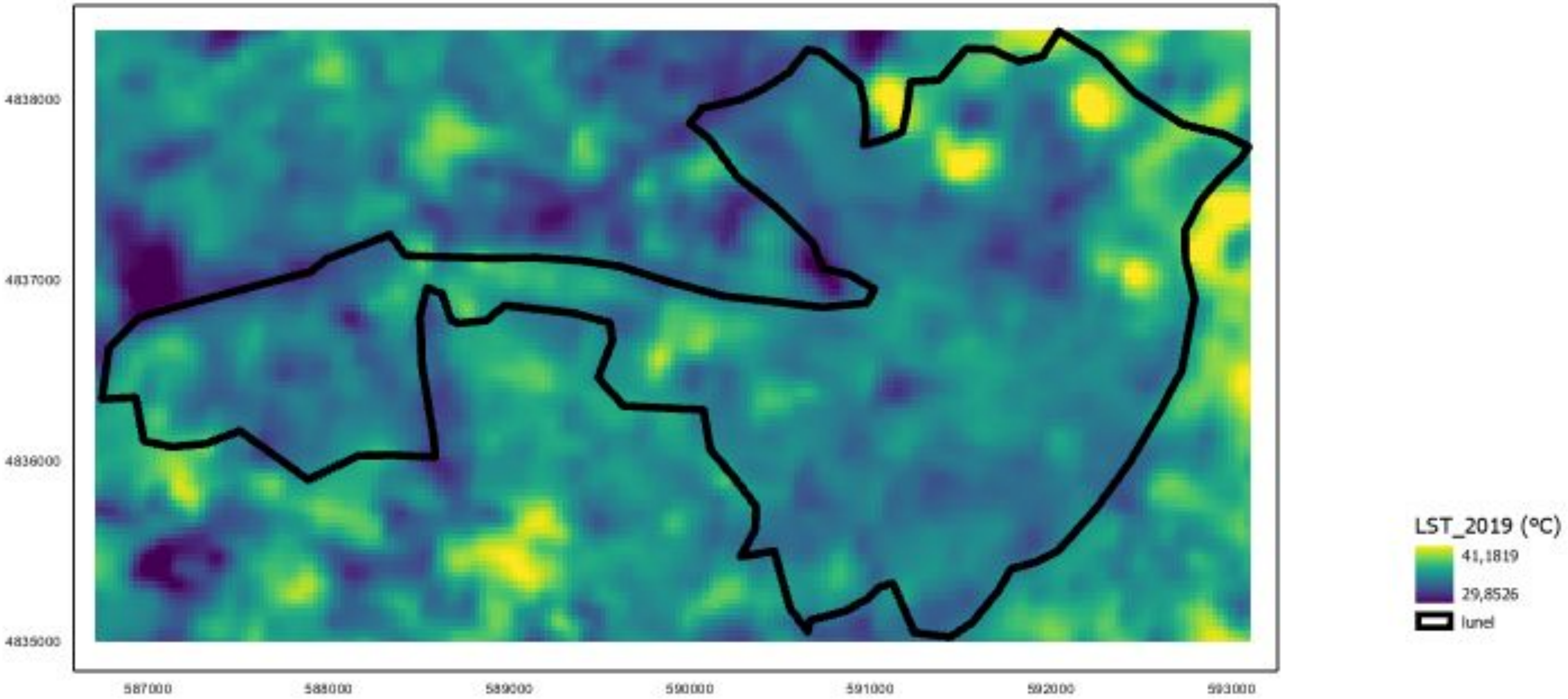



At-satellite Brightness Temperature to Land Surface Temperature

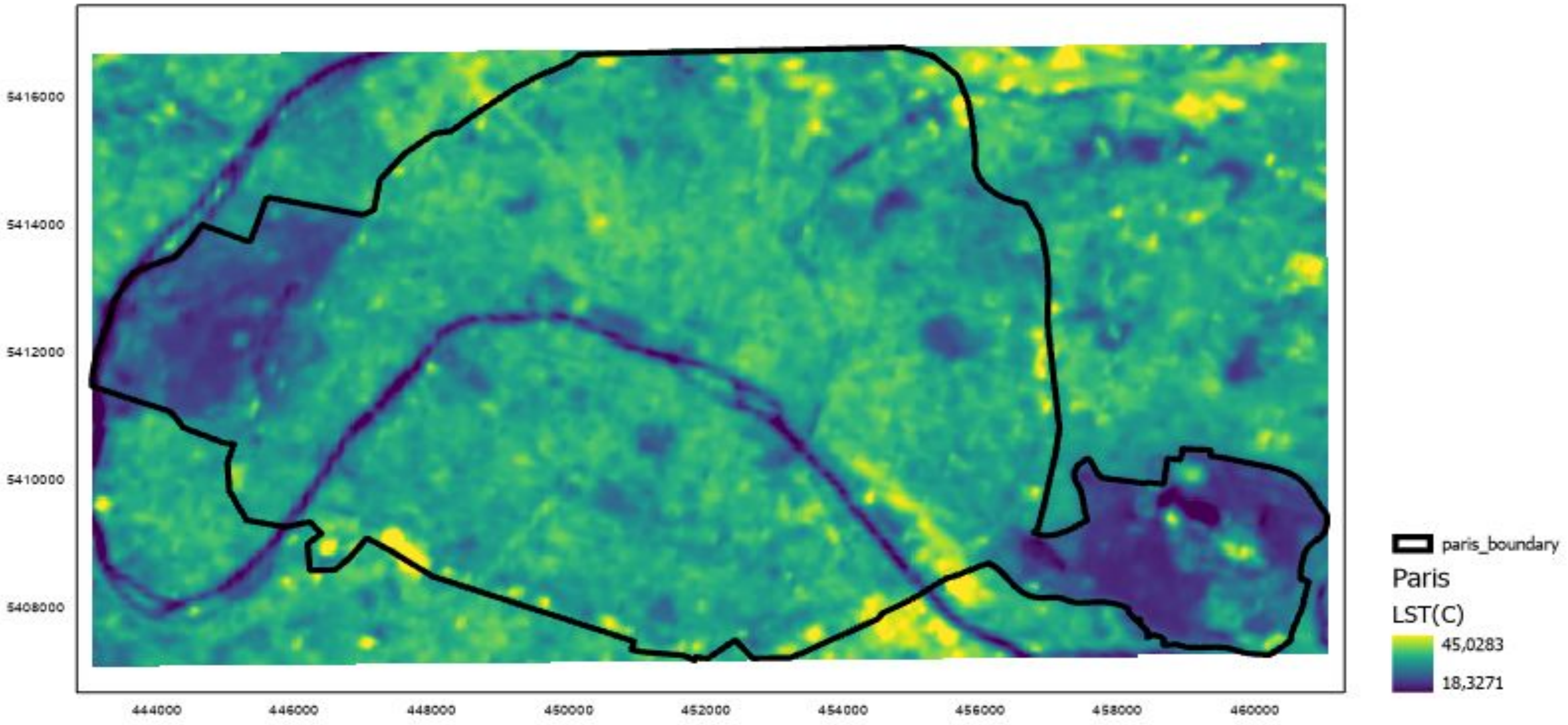
$$LST = \frac{BT}{(1 + [\langle \lambda BT/\rho \rangle * \ln LSE])}$$


LC08_L1TP_1...
B10
clip_b10_lune19
lune
Raster Calculator
toa_19_lune.tif
Raster Calculator (2)
bt_19_lune.tif
lst_19_lune.tif
Raster Calculator (6)
LC08_L1TP_1970...
B4
clip_b4_lune19
Raster Calculator (3)
pv_19_lune.tif
lse_19_lune.tif
lune (2)
Raster Calculator (5)
Raster Calculator (4)
ndvi_19_lune.tif
LC08_L1TP_1970...
B5
clip_b5_lune19
lune (3)

# ArcGIS Pro (Lunel, 2019)



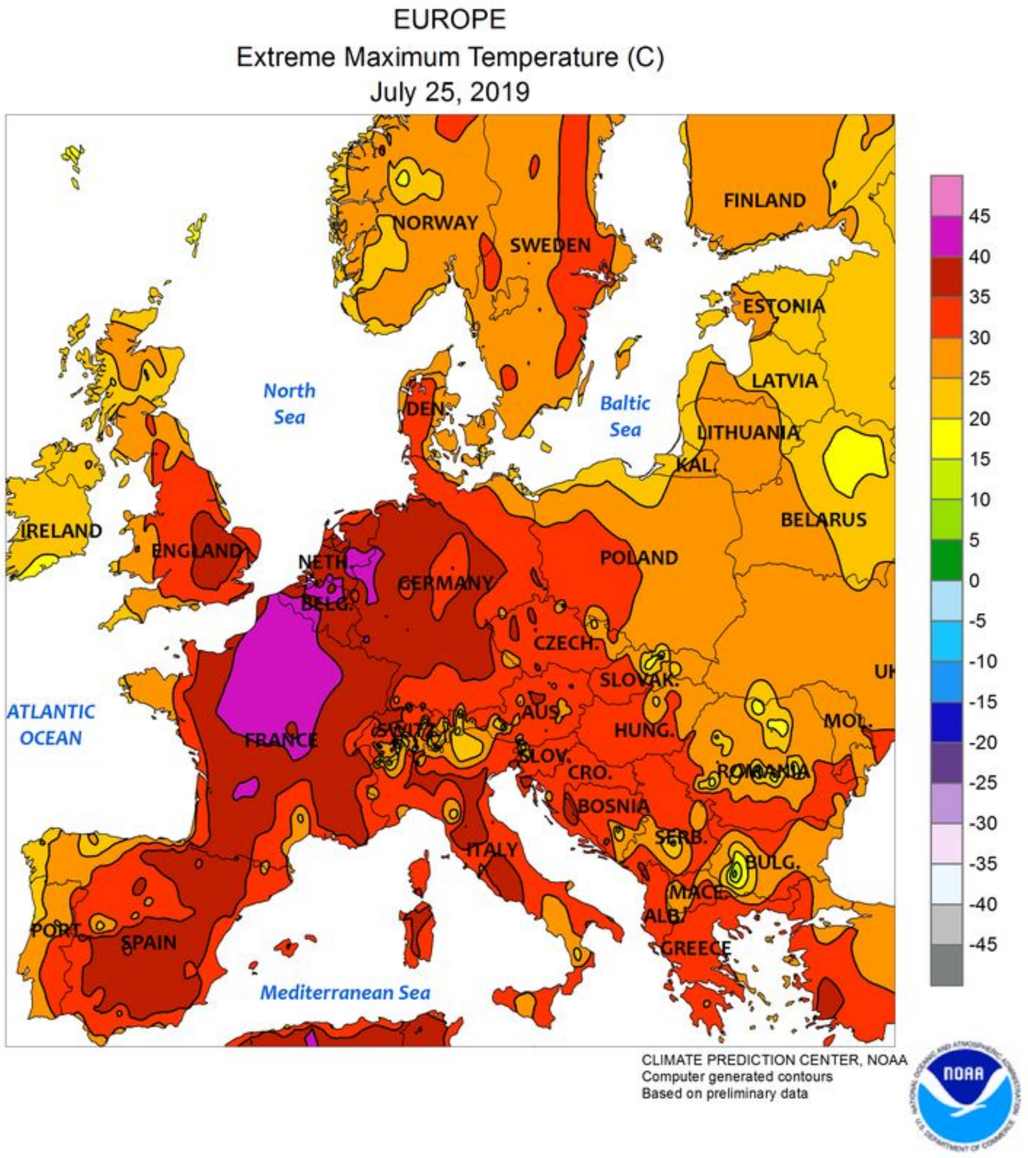
# ArcGIS Pro (Paris, 2019)



# Result Validation

In late June and late July 2019 there were two temporally distinct European heat waves, which set all-time high temperature records in Belgium, France, Germany, Luxembourg, the Netherlands, and the United Kingdom.

Source: Wikipedia, BBC



# GOOGLE EARTH ENGINE

# Google Earth Engine

## Google Earth Engine Open-Source Code for Land Surface Temperature Estimation from the Landsat Series

by Sofia L. Ermida [1,2,*], Patrícia Soares [3], Vasco Mantas [3], Frank-M. Göttsche [4] and Isabel F. Trigo [1,2]

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*Remote Sens.* **2020**, *12*(9), 1471; https://doi.org/10.3390/rs12091471

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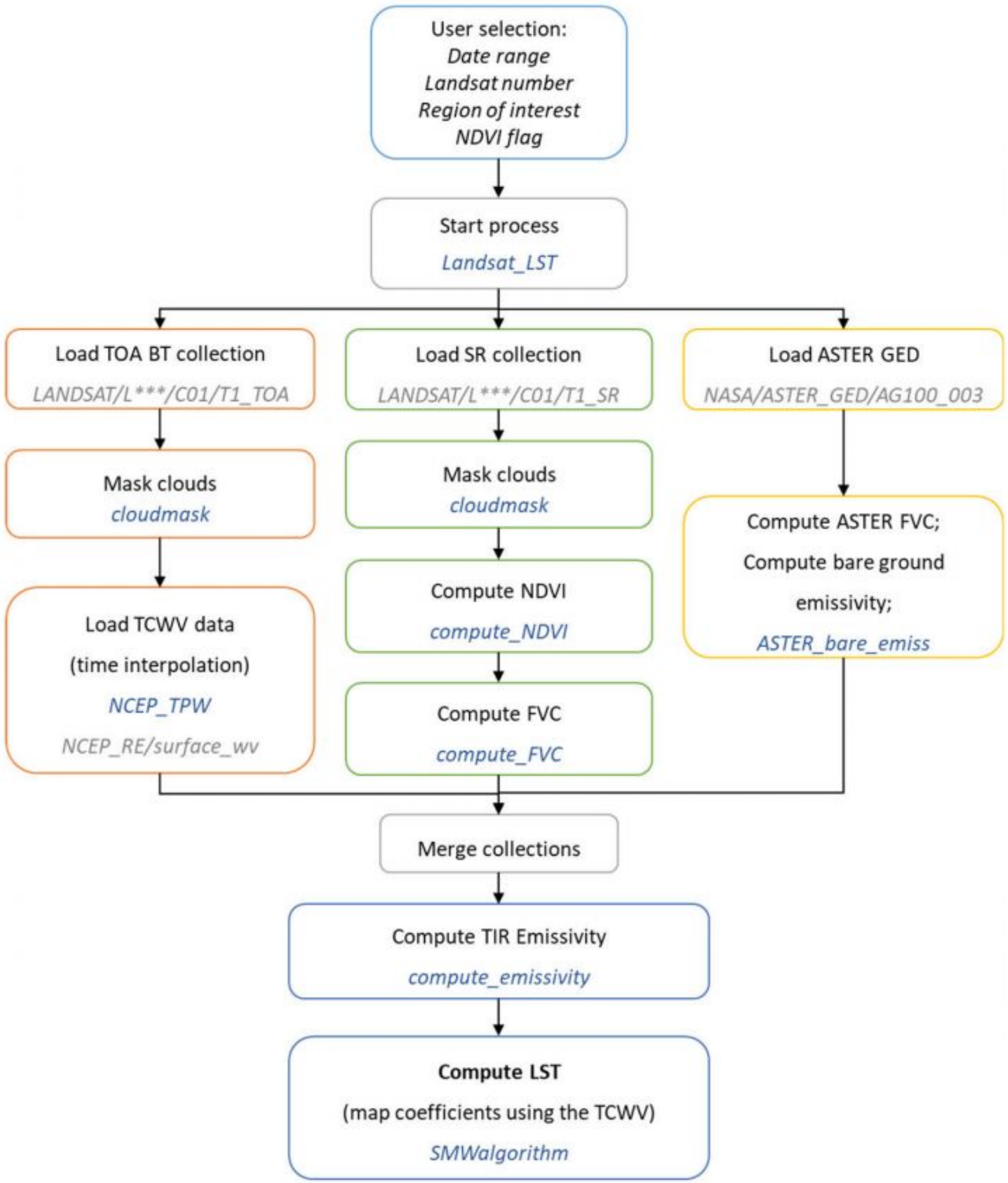
# Google Earth Engine

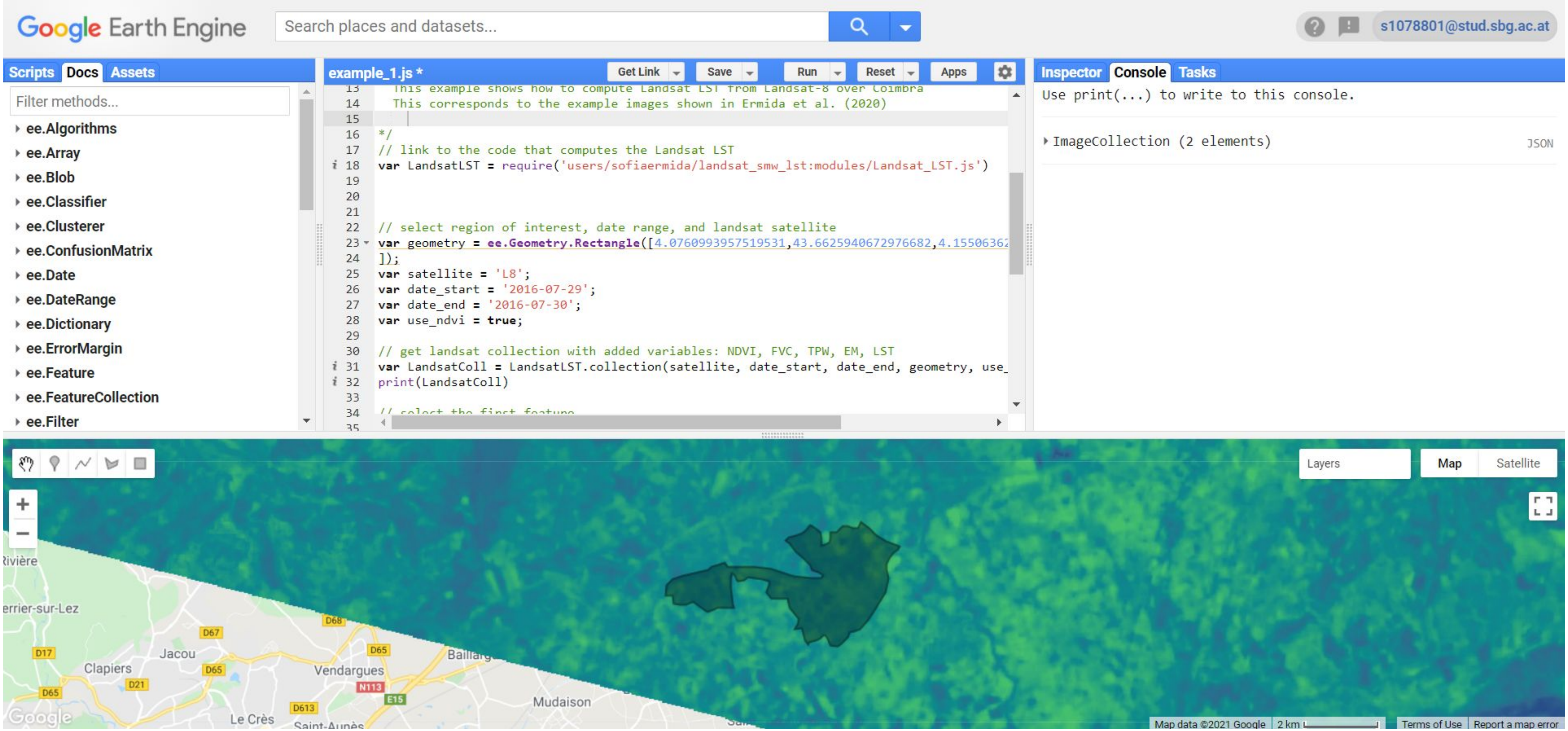
| Satellite | Used Bands | Wavelength (μm) | Dataset | Spatial Resolution | E.C.T. | Date Range |
|---|---|---|---|---|---|---|
| Landsat 4 (TM) | Red: B3<br>NIR: B4<br>TIR: B6 | 0.63–0.69<br>0.76–0.90<br>10.4–12.5 | C01/T1_SR<br>C01/T1_SR<br>C01/T1_TOA | 30 m<br>30 m<br>$120^2$ m | 9:45 am (16-day) | 22 August 1982 to 14 December 1993 |
| Landsat 5 (TM) | Red: B3<br>NIR: B4<br>TIR: B6 | 0.63–0.69<br>0.76–0.90<br>10.4–12.5 | C01/T1_SR<br>C01/T1_SR<br>C01/T1_TOA | 30 m<br>30 m<br>$120^2$ m | 9:45 am (16-day) | 1 January 1984 to 5 May 2012 |
| Landsat 7 (ETM+) | Red: B3<br>NIR: B4<br>TIR: B6[1] | 0.63–0.69<br>0.77–0.90<br>10.4–12.5 | C01/T1_SR<br>C01/T1_SR<br>C01/T1_TOA | 30 m<br>30 m<br>$60^2$ m | 10:00 am (16-day) | 1 January1999 to present |
| Landsat 8 (OLI; TIRS) | Red: B4<br>NIR: B5<br>TIR: B10 | 0.64–0.67<br>0.85–0.88<br>10.6–11.19 | C01/T1_SR<br>C01/T1_SR<br>C01/T1_TOA | 30 m<br>30 m<br>$100^2$ m | 10:00 am (16-day) | 11 April 2013 to present |

Note: [1] low gain band (B6_VCID_1); [2] resampled to 30 m.

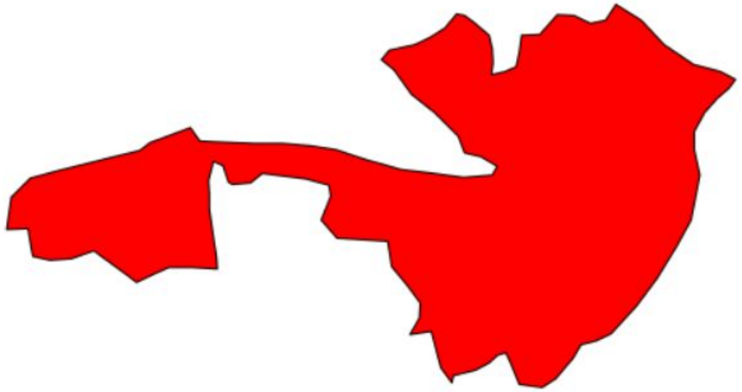


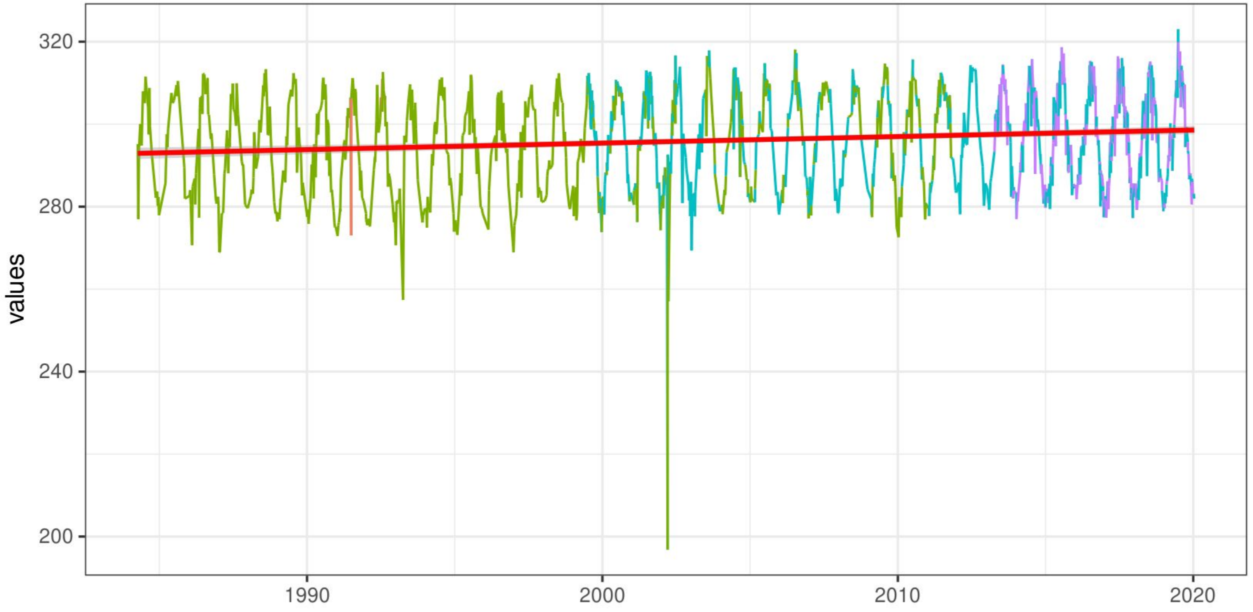

[Ermida et al, 2020](#)

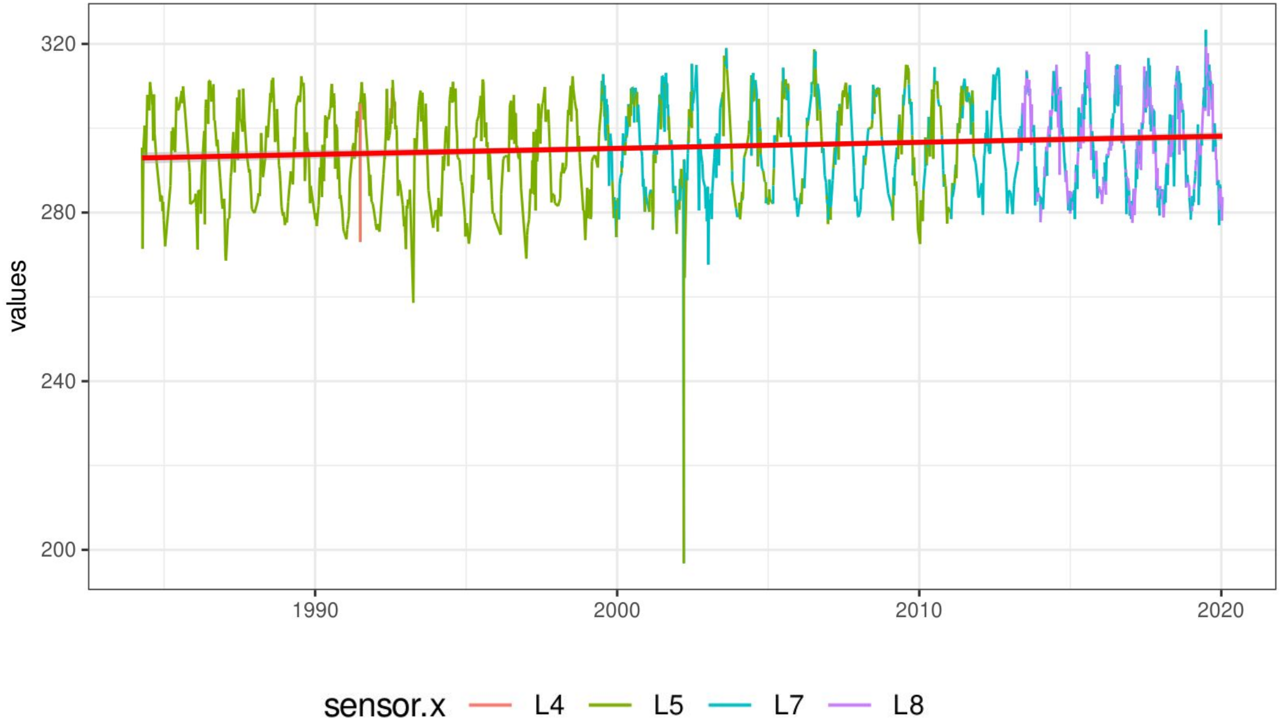
# Google Earth Engine



# Google Earth Engine





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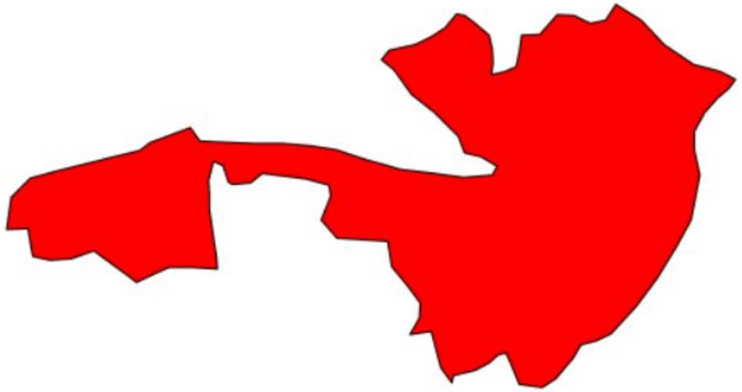
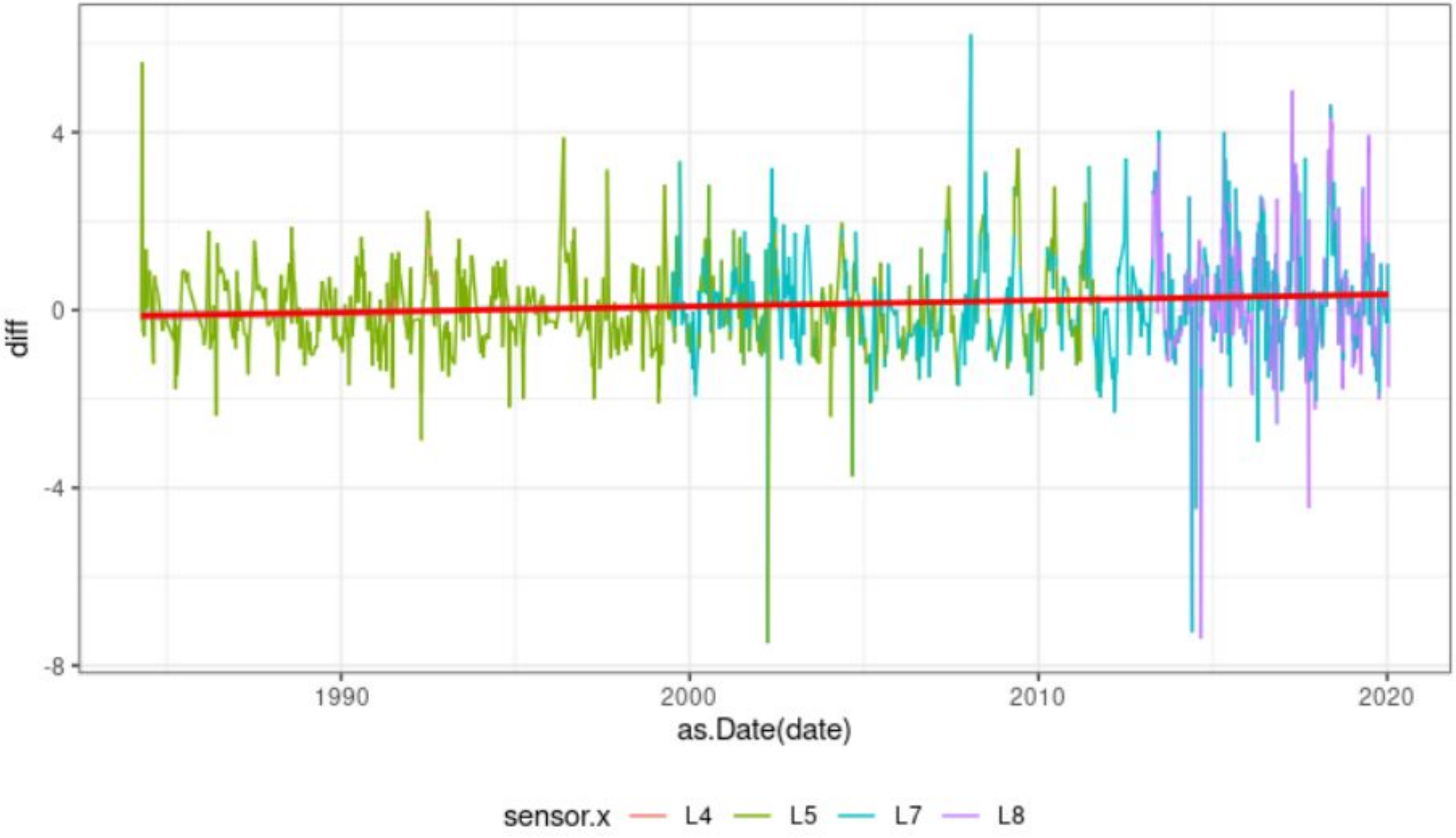
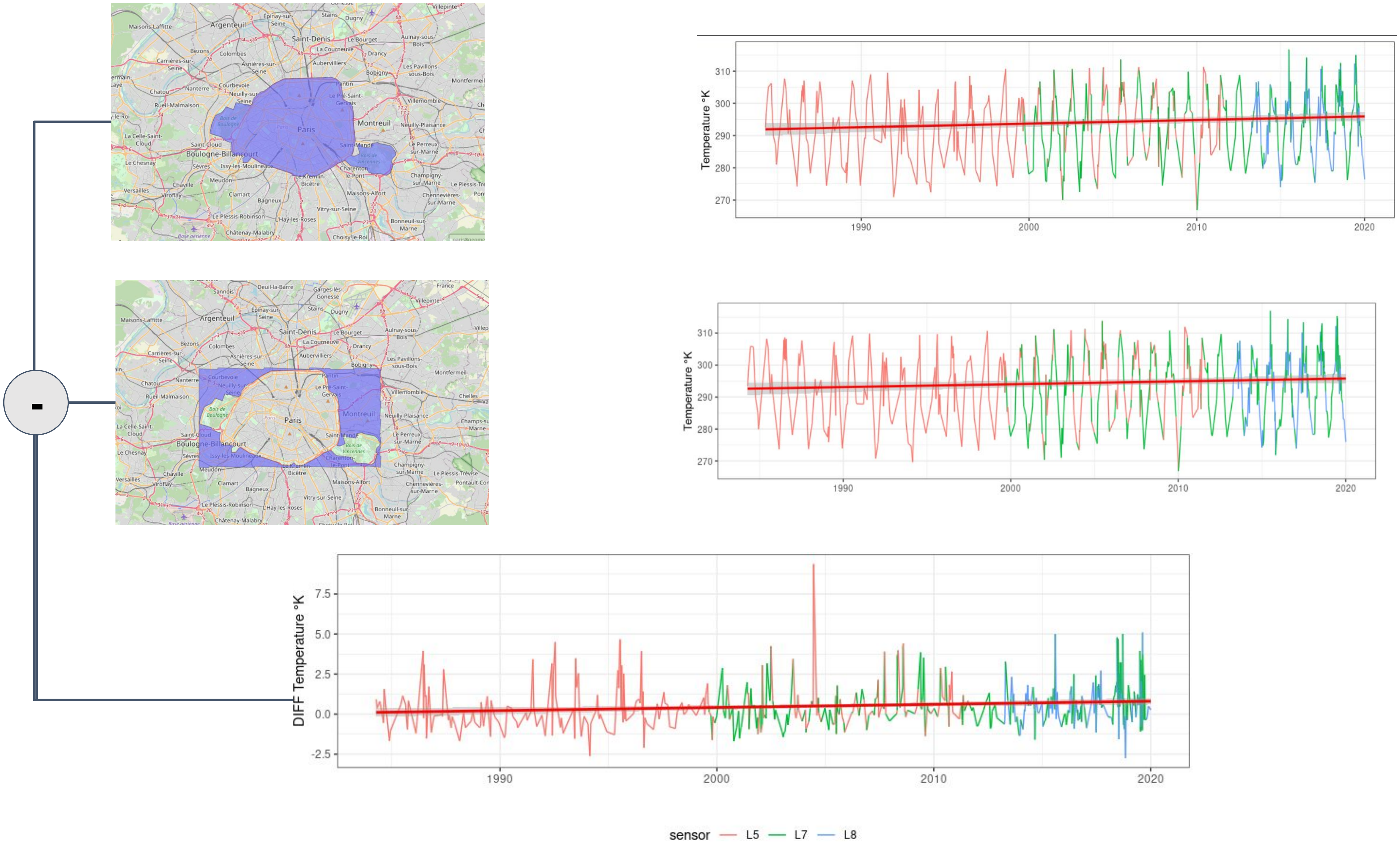
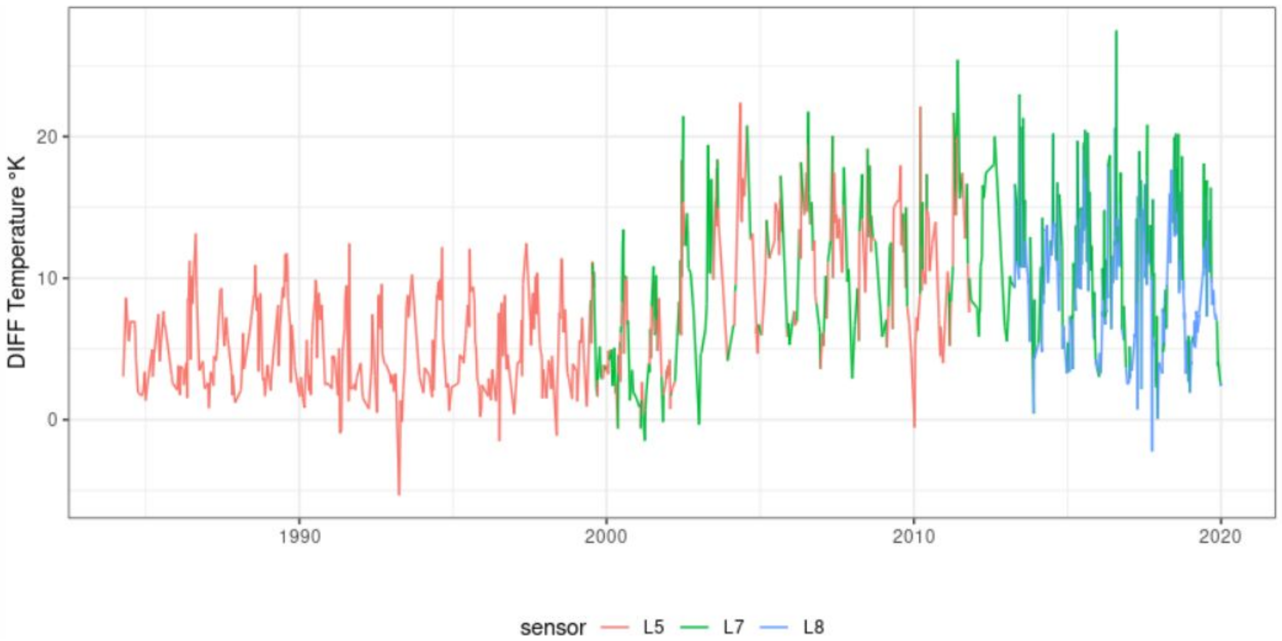




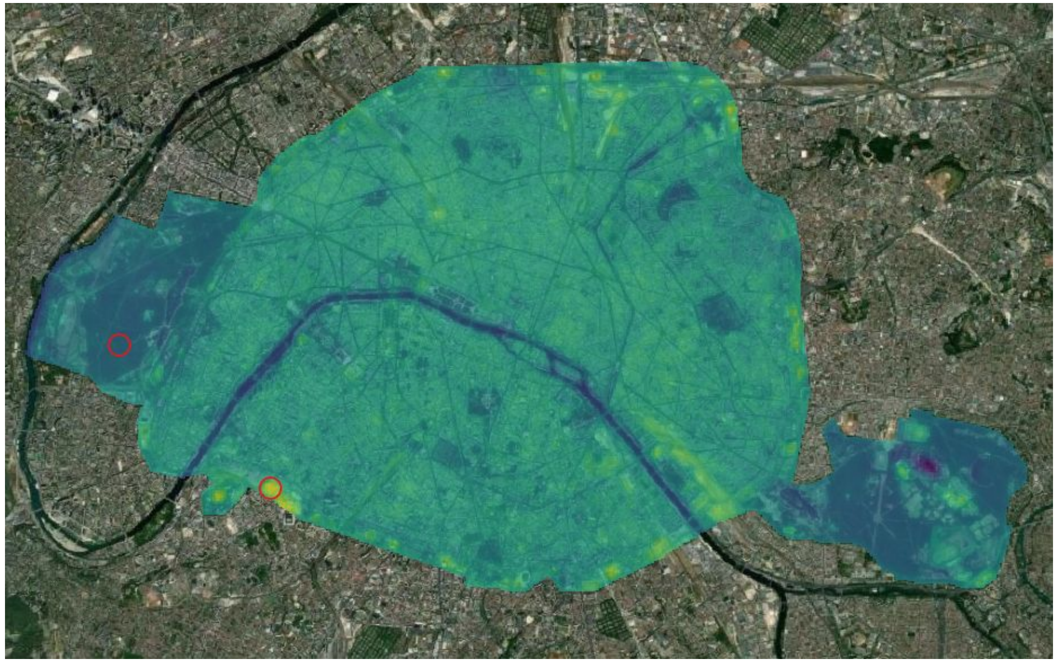


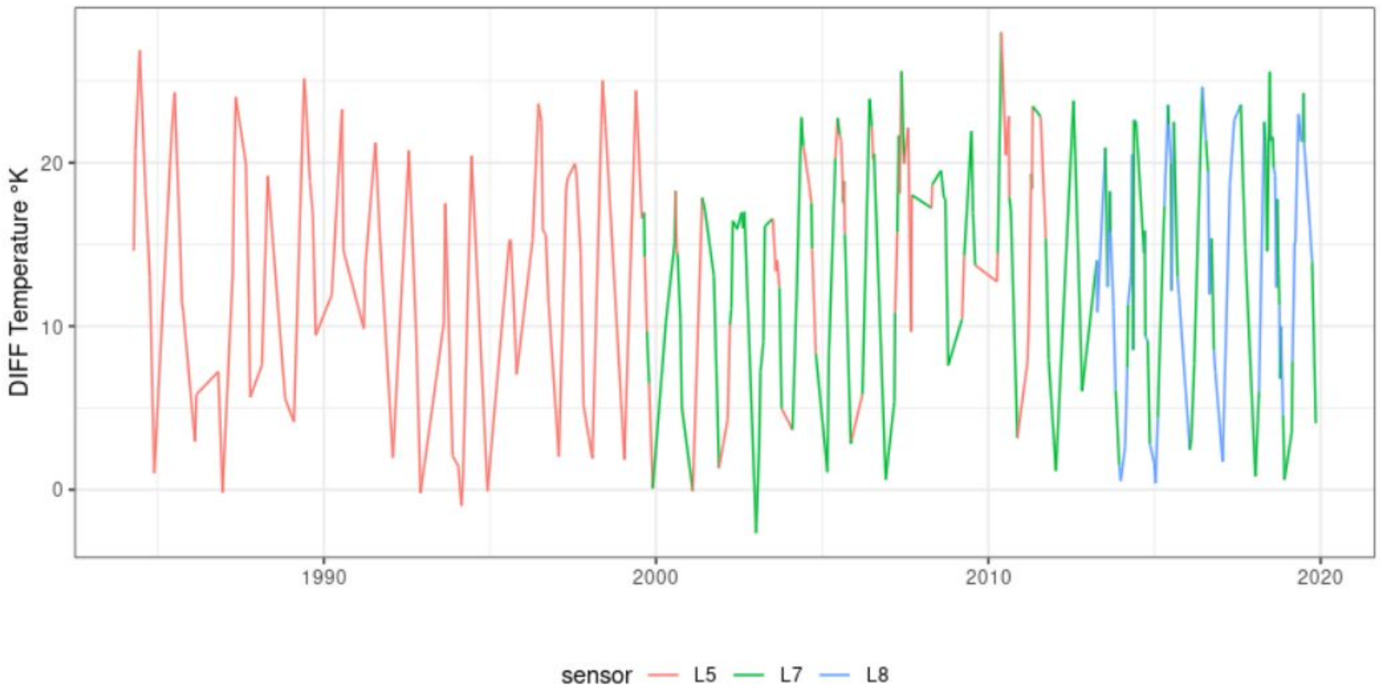
Paris
Temperature °K
310
300
290
280
270
1990
2000
2010
2020
-
DIFF Temperature °K
7.5
5.0
2.5
0.0
-2.5
sensor
L5
L7
L8

# Google Earth Engine (Lunel, 2019)



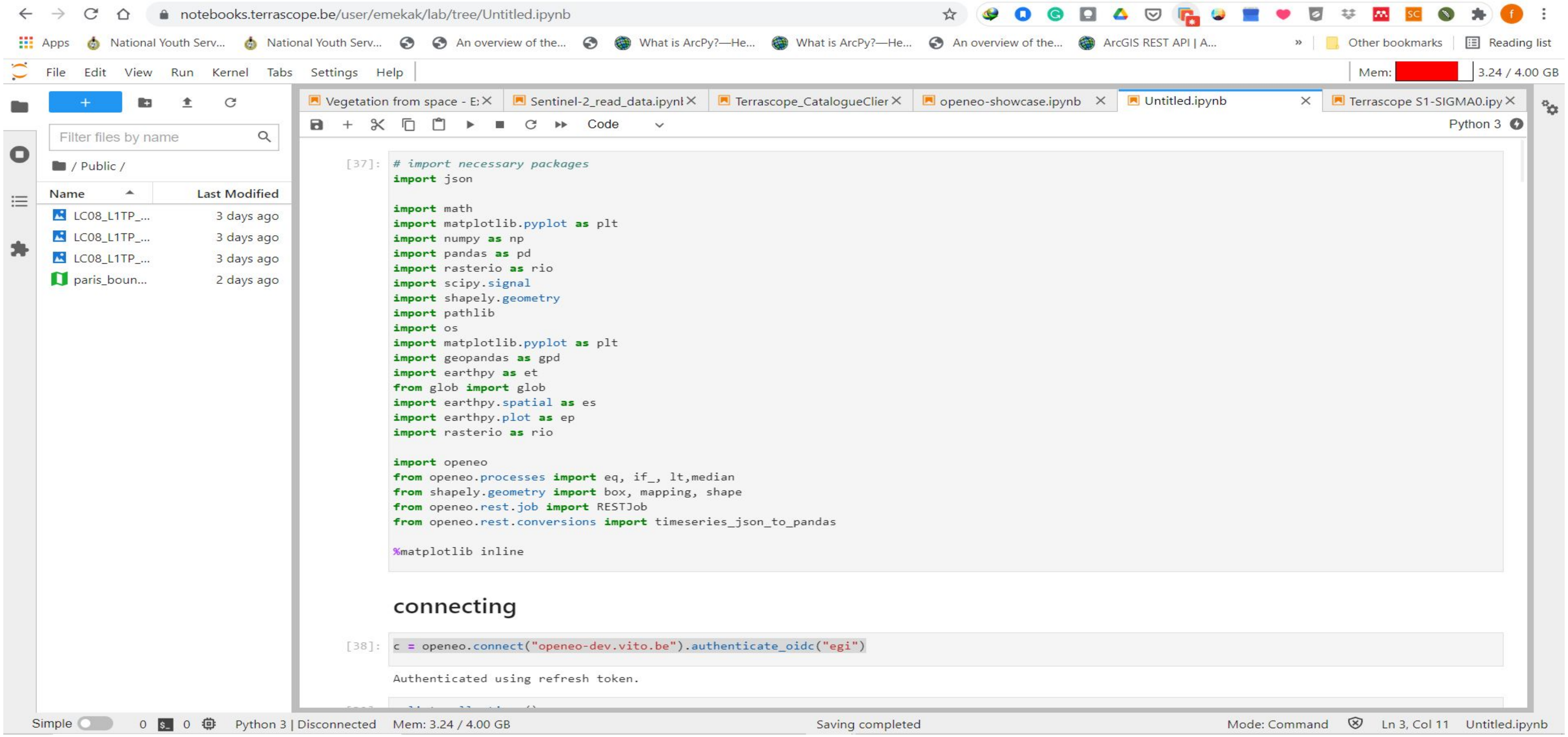
# Google Earth Engine (Paris, 2019)





TERRA
SCOPE

# Terrascope


notebooks.terrascope.be/user/emekak/lab/tree/Untitled.ipynb
File Edit View Run Kernel Tabs Settings Help
Mem: 3.24 / 4.00 GB
Filter files by name
/ Public /
Name
Last Modified
LC08_L1TP_... 3 days ago
LC08_L1TP_... 3 days ago
LC08_L1TP_... 3 days ago
paris_boun... 2 days ago
Vegetation from space - E:
Sentinel-2_read_data.ipynb
Terrascope_CatalogueClier
openeo-showcase.ipynb
Untitled.ipynb
Terrascope S1-SIGMA0.ipy
Code
Python 3
[37]: # import necessary packages
import json
import math
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import rasterio as rio
import scipy.signal
import shapely.geometry
import pathlib
import os
import matplotlib.pyplot as plt
import geopandas as gpd
import earthpy as et
from glob import glob
import earthpy.spatial as es
import earthpy.plot as ep
import rasterio as rio
import openeo
from openeo.processes import eq, if_, lt,median
from shapely.geometry import box, mapping, shape
from openeo.rest.job import RESTJob
from openeo.rest.conversions import timeseries_json_to_pandas
%matplotlib inline
connecting
[38]: c = openeo.connect("openeo-dev.vito.be").authenticate_oidc("egi")
Authenticated using refresh token.
Simple
Python 3 | Disconnected
Mem: 3.24 / 4.00 GB
Saving completed
Mode: Command
Ln 3, Col 11
Untitled.ipynb

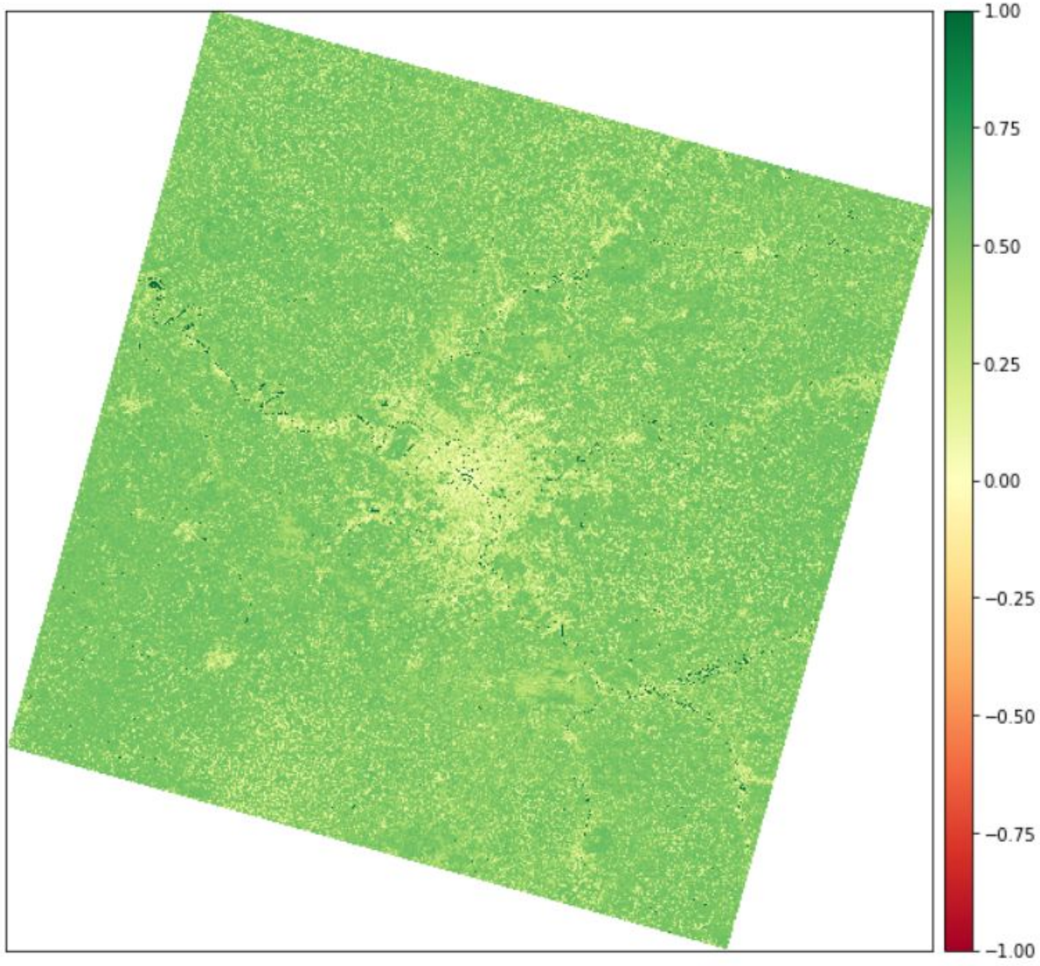
# Terrascope (Paris, 2019)

NDVI Computation

```
S_l8tirs_bands
```

```
['Public/LC08_L1TP_199026_20190602_20200828_02_T1_B10.TIF',
 'Public/LC08_L1TP_199026_20190602_20200828_02_T1_B4.TIF',
 'Public/LC08_L1TP_199026_20190602_20200828_02_T1_B5.TIF']
```

```
ndvi = es.normalized_diff(arr_st[2], arr_st[1])
ep.plot_bands(ndvi, cmap="RdYlGn", cols=1, vmin=-1, vmax=1, figsize=(10, 14))
plt.show()
```



# Conclusions

Extreme weather events like heatwaves occur naturally but research shows that with climate change they are likely to become more common, perhaps occurring as regularly as every other year.

Rapid warming is linked to use of fossil fuels and the higher concentration of carbon dioxide (a greenhouse gas) in the atmosphere.