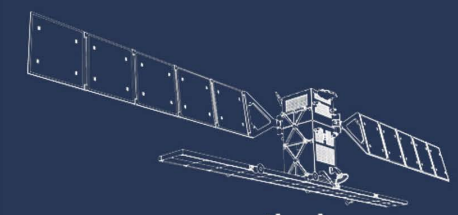
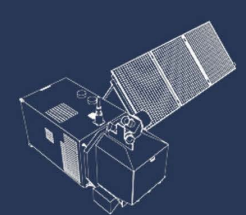
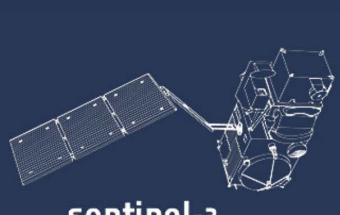
UNIVERSITY COURSE EARTH OBSERVATION WITH ESA MISSIONS

# TUTORIAL FOR EXERCISE 7

## Urban Heat Island using ESA satellite data Sentinel-3

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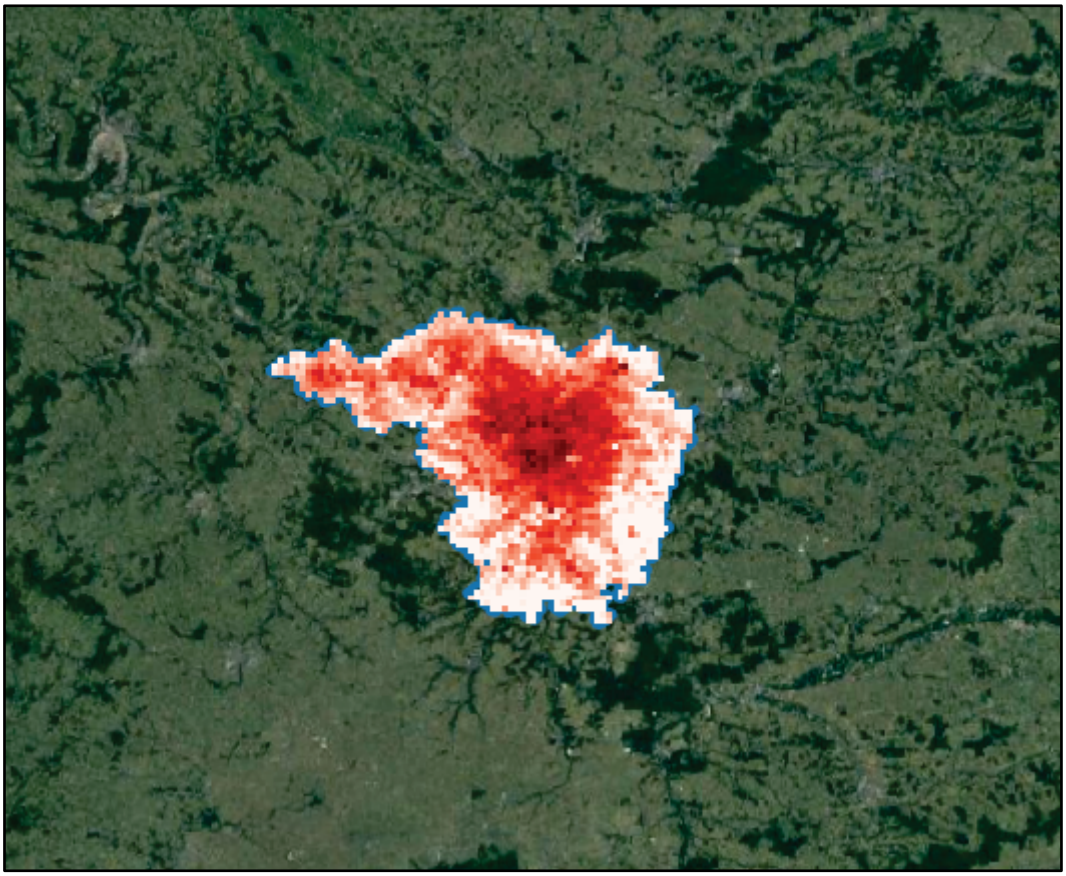
# Table of Content

# 1 Exercise outline

In this exercise, we will:

- learn what is Urban Heat Island effect and what causes it
- understand the Sentinel-3 LST product and know what it is used for
- learn how to use land cover / land use band for extraction of land temperature
- extract the mean temperature value by means of Pin placing tool and SNAP Statistics tool
- analyze and classify the increase in surface temperature
- visualize the resulting Urban Heat Island map clipped of an interesting area



## 2 Urban Heat island detection

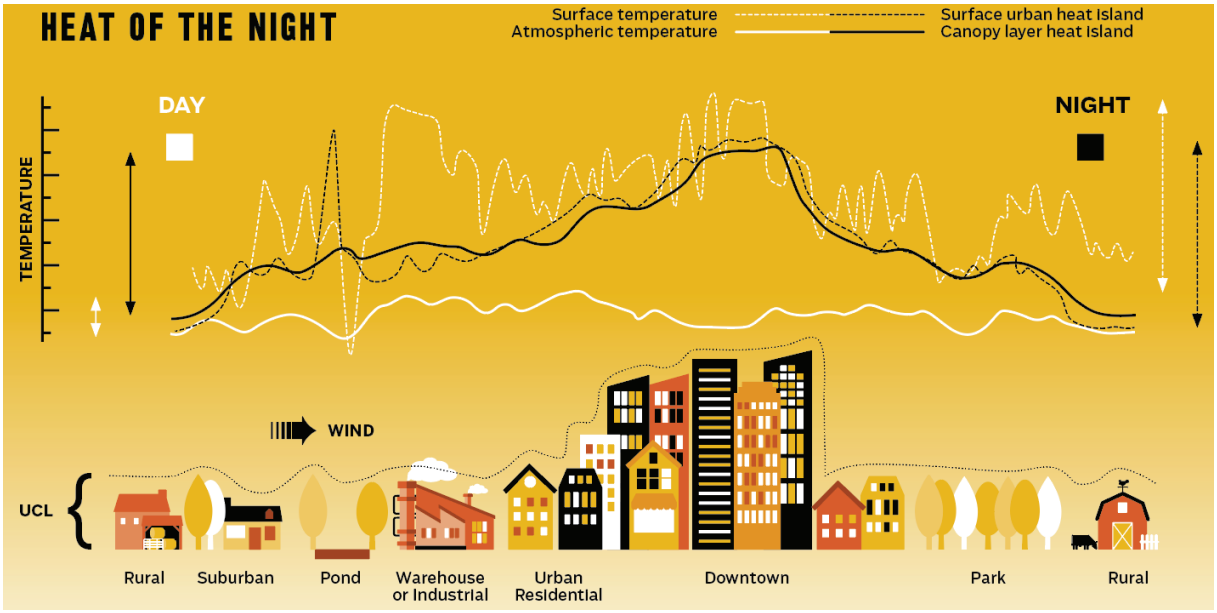
More than half of the world's population currently lives in urban areas. This trend is expected to continue. Rapid urbanization has a positive impact on economic growth. However, the negative effects of urbanization on a global scale are also widespread. These include in particular:

- Loss of natural habitats
- Changes in biodiversity
- Climate impacts
- Environmental pollution
- And other factors

A typical example of the impact of urbanised areas on the local climate is urban heat island (UHI) effect. This climate effect causes:

- Transformation of mechanical energy into heat
- Lower albedo of the urban environment compared to the surrounding area
- Atmospheric aerosols in the air

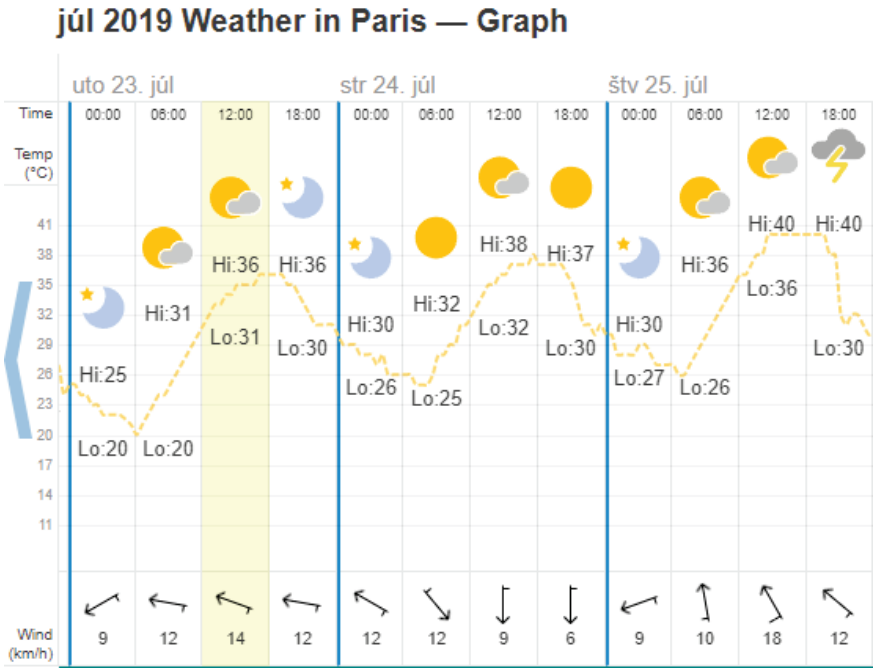
The result is faster warming of urban zones compared to non-urbanised surroundings. Air temperature in densely urbanised areas is higher than in suburbs and rural areas. Highest intensity in winter, during high atm. pressure, windless, evening, night, early morning.




*Source: https://www.createdigital.org.au/wp-content/uploads/2018/12/urban-heat-2.png*

## 2.1. Study area and image download

The study area is situated in capital city of France Paris. in July 2019, a 70-year temperature record was set in Paris. The highest temperature was up to 41 degrees Celsius. Temperature records also set in other cities in France and other European capitals.



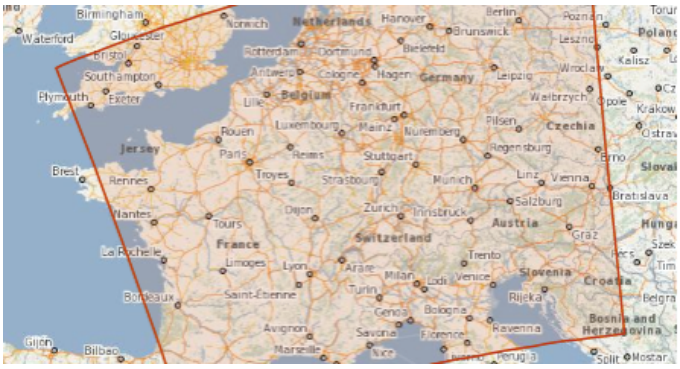
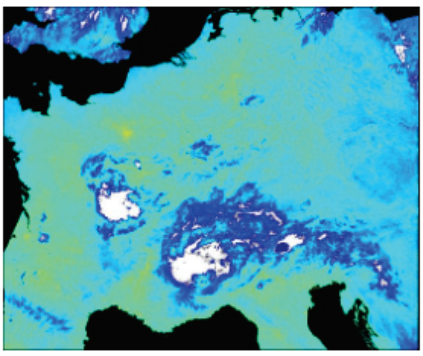

*Source: https://www.timeanddate.com/weather/france/paris/historic?month=7&year=2019*

ESA`s Sentinel-3 Sea and Land Surface Temperature Radiometer instrument provides a reference dataset of land surface temperature and sea surface temperature. Capable of determining global sea surface temperature to better than 0.3 K (0.3 °C; 0.5 °F. SLSTR products are provided in 2 levels. Level 2 products consist of marine and terrestrial geophysical quantities divided to 4 types (FRP, AOD, LST, and WCT). One of them is LST - Land surface temperature used for this exercise.

Download images:

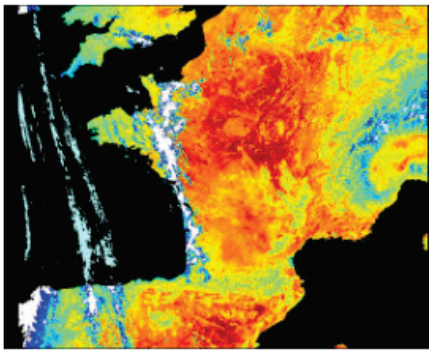
Night acquisition

S3A_SL_2_LST____20190724T210604_20190724T210904_20210120T092625_0179_047_200_0720_LR1_R_NT_004

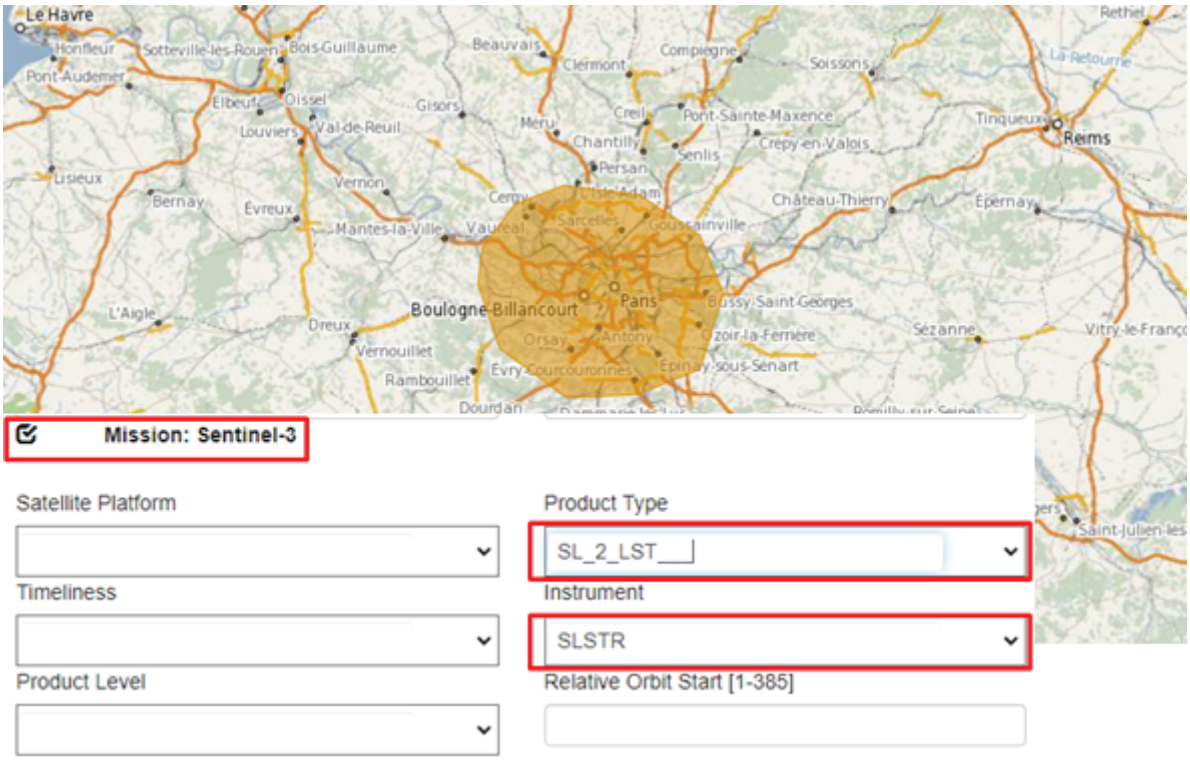
Day acquisition

S3B_SL_2_LST____20190725T101824_20190725T102124_20200820T171634_0179_028_065_2160_LR1_R_NT_004

from Copernicus Open Access Hub

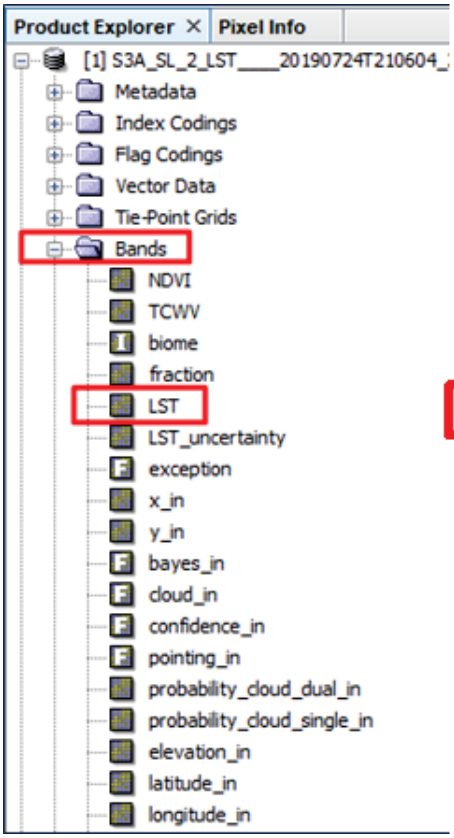
[*https://scihub.copernicus.eu/dhus/#/home*]

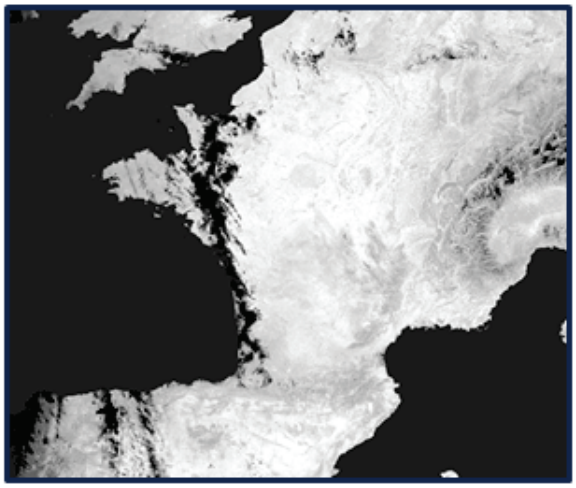

Le Havre
Honfleur
Sotteville-lès-Rouen
Bois-Guillaume
Beauvais
Clermont
Compiègne
Soissons
Pont-Audemer
Elbeuf
Oissel
Gisors
Louviers
Val-de-Reuil
Méru
Creil
Pont-Sainte-Maxence
Chantilly
Crépy-en-Valois
Senlis
Tinqueux
Reims
Lisieux
Bernay
Évreux
Vernon
Persan
Cergy
Château-Thierry
Épernay
Mantes-la-Ville
Vaureal
Sarcelles
Gouvieux
Boulogne-Billancourt
Paris
Bussy-Saint-Georges
L'Aigle
Dreux
Orsay
Antony
Ozoir-la-Ferrière
Sézanne
Vitry-le-Franç
Vernouillet
Rambouillet
Évry-Courcouronnes
Épinay-sous-Sénart
Dourdan
Saint-Julien-les
Mission: Sentinel-3
Satellite Platform
Product Type
SL_2_LST___
Timeliness
Instrument
SLSTR
Product Level
Relative Orbit Start [1-385]

## 2.2. Image pre-processing

### Opening LST band

Firstly, we will import both Sentinel-3 LST images for determining the temperature of the Earth's surface (band LST)

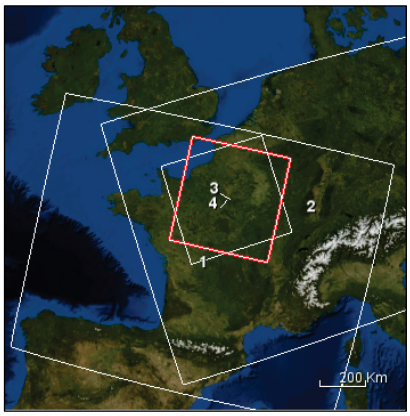


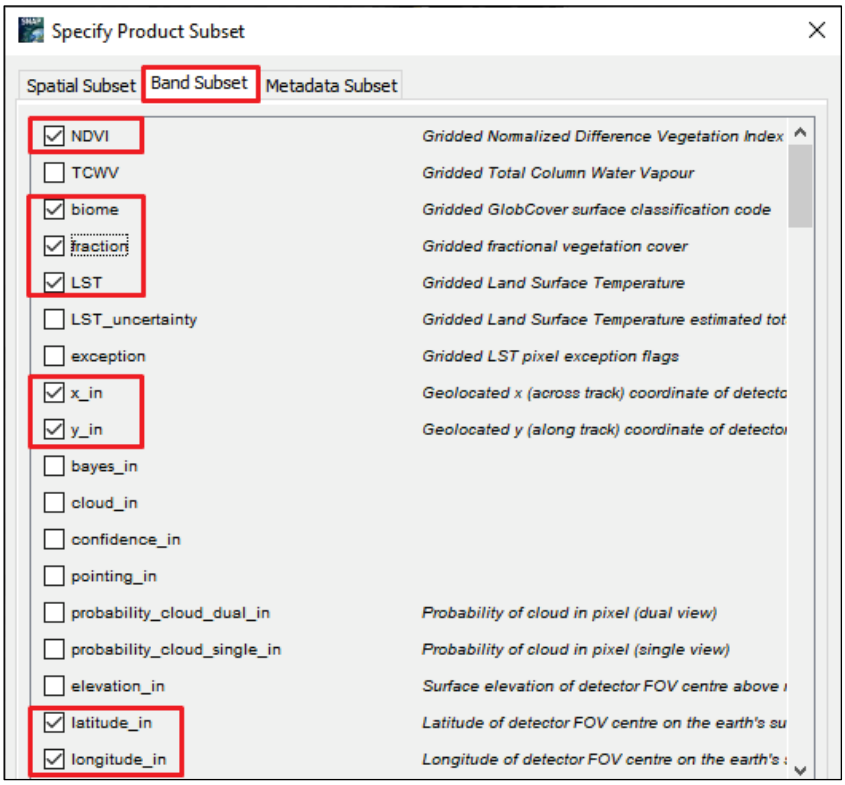
### Subset

Secondly, we will create a cutout of the image using the Raster - Subset tool. For change the original scale of the image we will use Spatial Subset tab. For this case study we will use the following Geo coordinates:

| | |
|---|---|
| N | 51.000 |
| W | 0.200 |
| S | 46.000 |
| E | 4.500 |

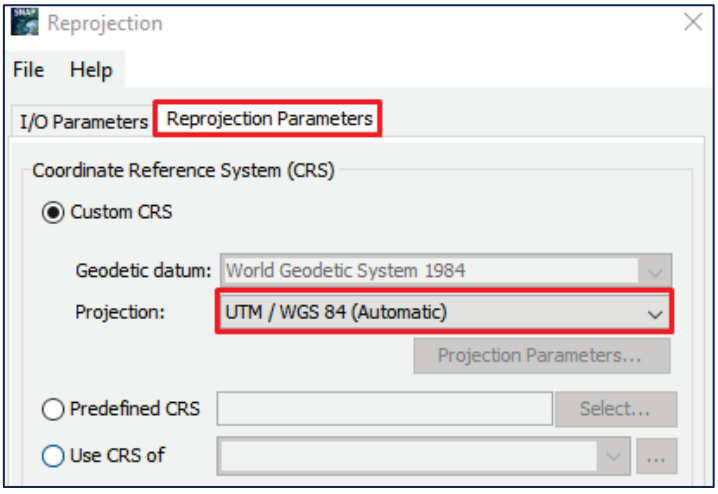


The next step is to reduce bands using Band Subset function. When creating a subset, it is advisable to select the bands needed for processing purposes only, shown in the following figure.




## Reprojection

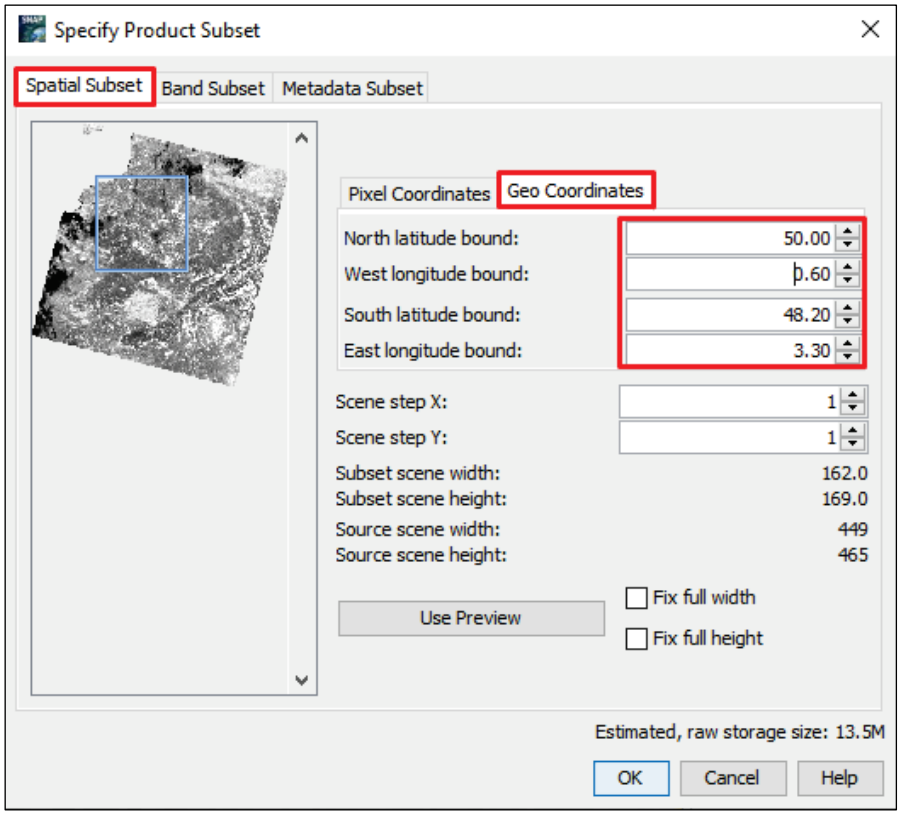
In this step Sentinel-3 SLSTR product cut-outs need to be reprojected. Therefore, it is necessary to select and choose the most appropriate type of map projection for the given image (in this case - UTM / WGS84). This function is available by Raster - Geometric operations - Reprojection option (need to check the output file path.




## Final image subset

After the reprojection we will make the final image subset to refine the location of interest using the Raster - Subset tool with following coordinates:

| | |
|---|---|
| N | 50.000 |
| W | 0.600 |
| S | 48.200 |
| E | 3.300 |

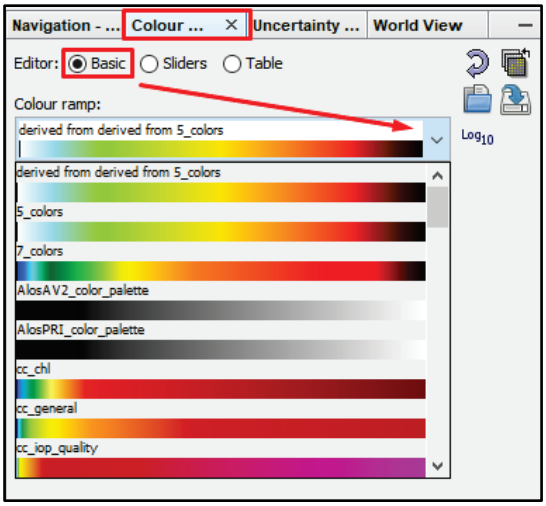



After this step we obtain the final extent of the area of interest. Also we can rename files as LST_20190724_night and LST_20190725_day for better orientation.

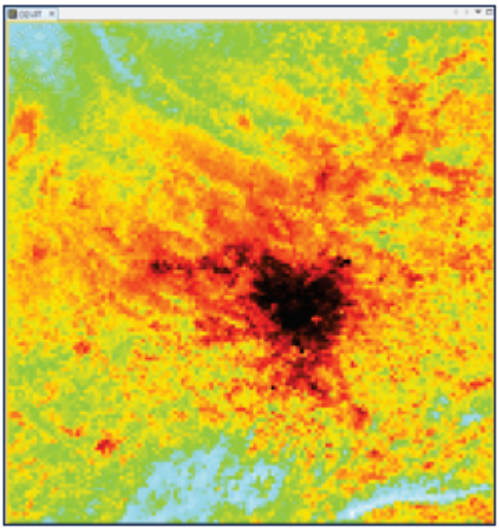
## 2.3. Image temperature comparison

### Visual comparison of both images temperature

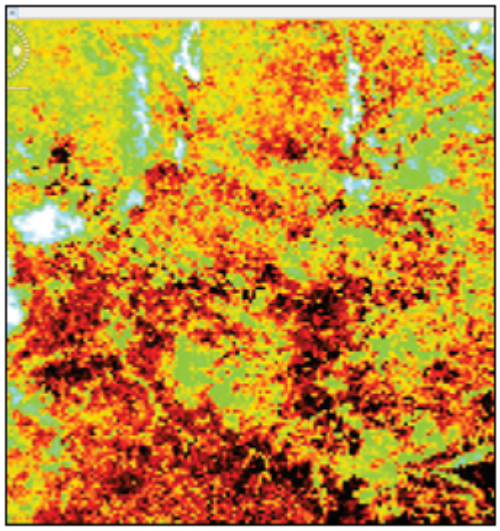
Firstly, View final products in the Product Explorer panel and visualize LST bands. For better visual representation we click in the Colour Manipulation panel and Basic tab and select the 5_color "ramp" colour scale. It is also advisable to set minimum and maximum temperature values




After opening both LST products in a horizontal tiling window, we identify day versus night differences. Temperature values are given in Kelvin (K), according to the relationship C = K + 273.15

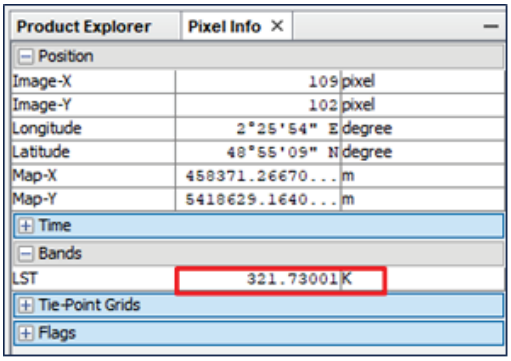


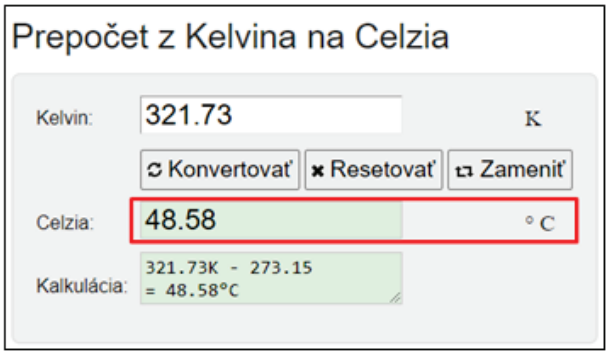
Night



Day

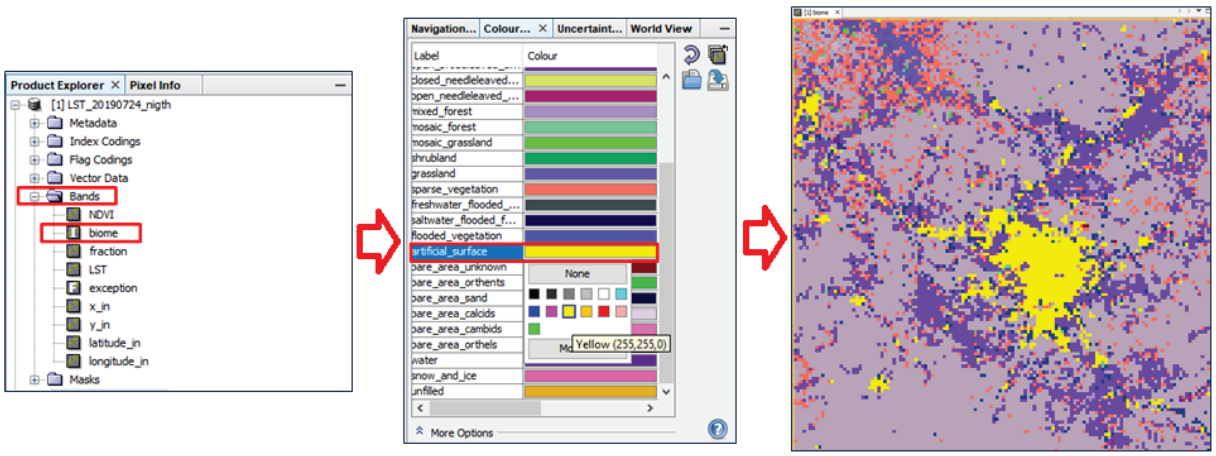
Pixel Info panel shows temperature for individual pixels in the LST band with their geographic coordinates. if you want to convert K to °C, you can use any available online converter.



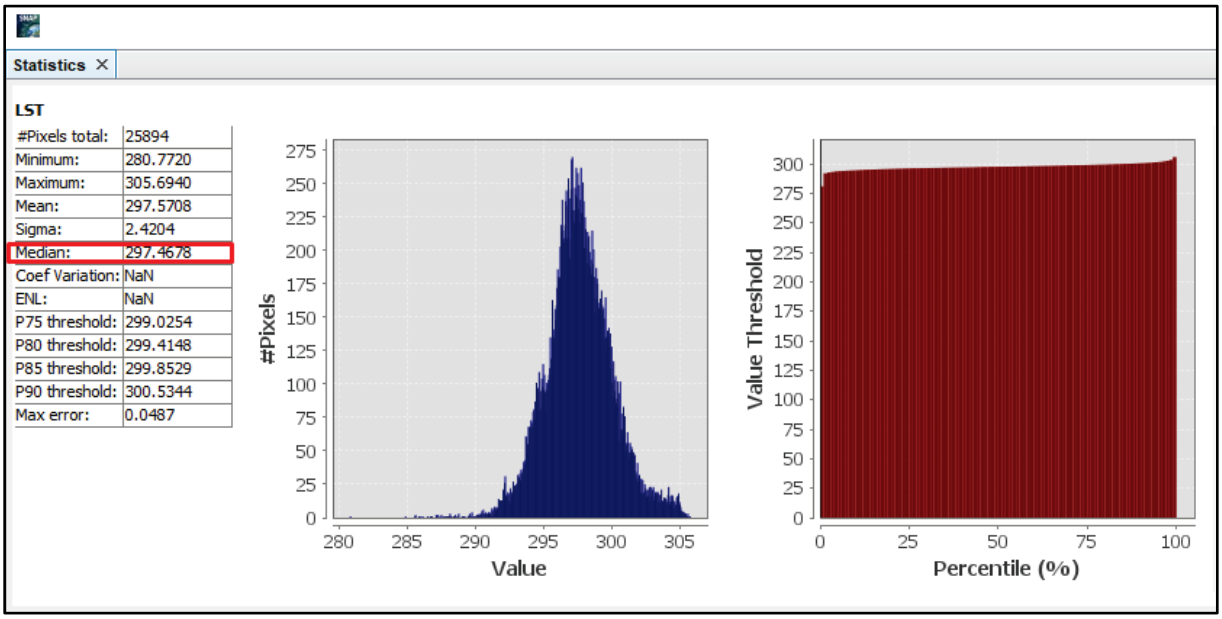



Import land cover band

To more easily identify the influence of urbanised areas on temperature, it is useful to subtract the average temperature of non-urbanised areas outside the city. For that, we first add a land cover band to identify different land cover / land use or use a LUC band called a biome.

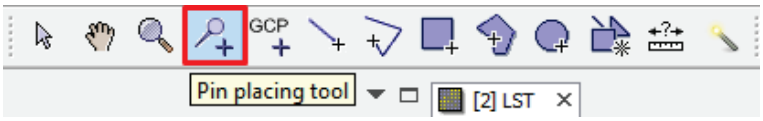



Finding the mean temperature value for a given image - using the Statistics panel.

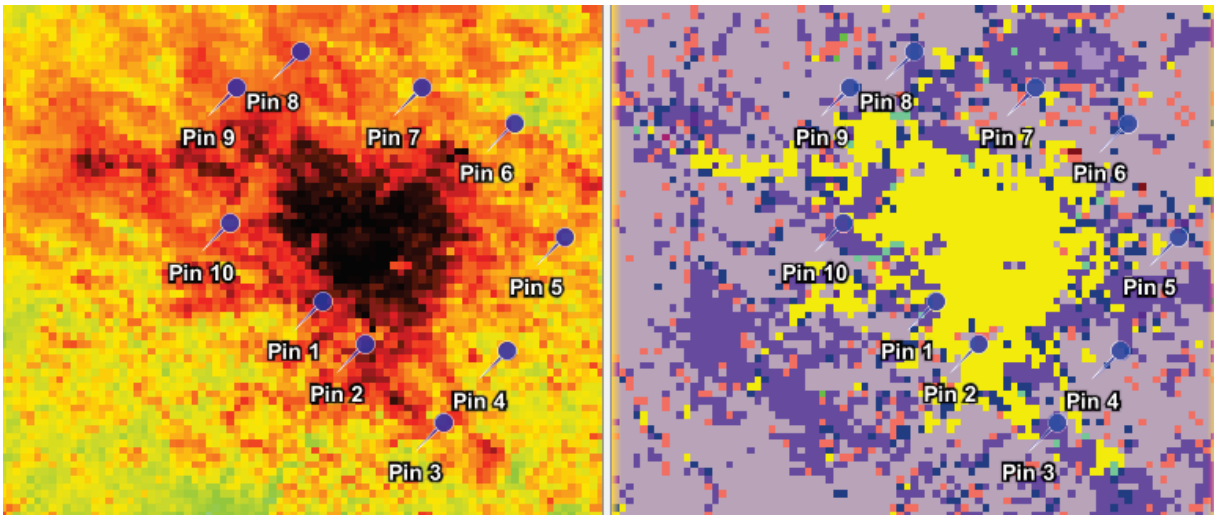



## 2.4. Extracting the mean temperature value

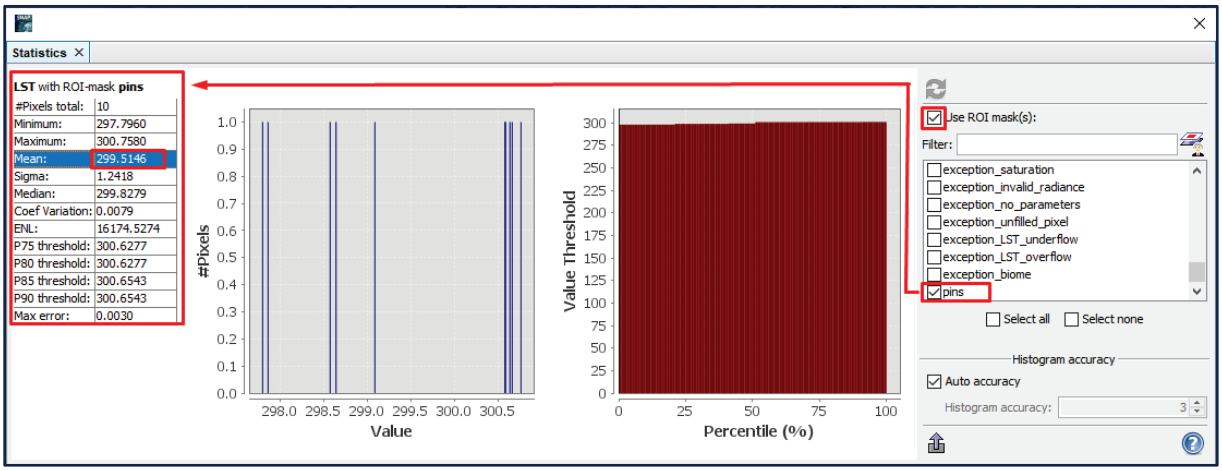
The next step is to derive the mean temperature around Paris through specific pixel values. A suitable tool for this control point placement is the Pin placing tool.




Optimal number of approximately 10 control points. Based on the control points, it is possible to derive a mean temperature value.



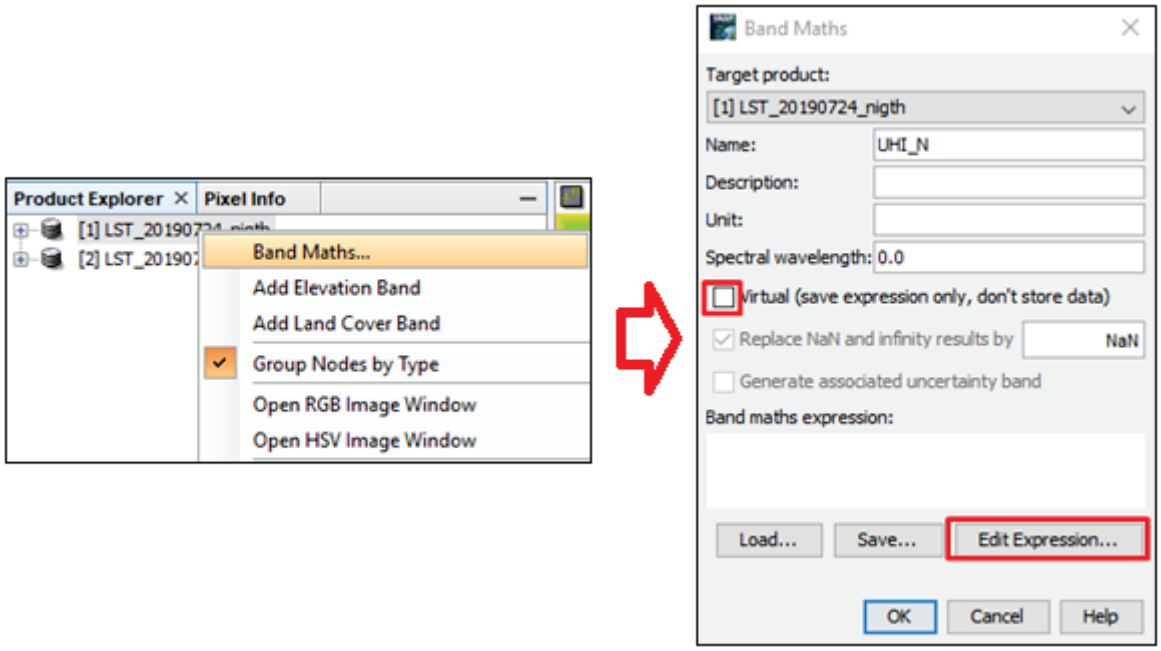

Then, we can derive the mean temperature value for the pixels identified by the pins using the statistical tool of SNAP (Analysis – Statistics. We select the option Select ROI Mask(s), go down in the list and select pins. In the next step, we press the refresh button. From the panel on the right, the mean temperature value can be extracted at 299.5146K (night) and 318.2048K (day).



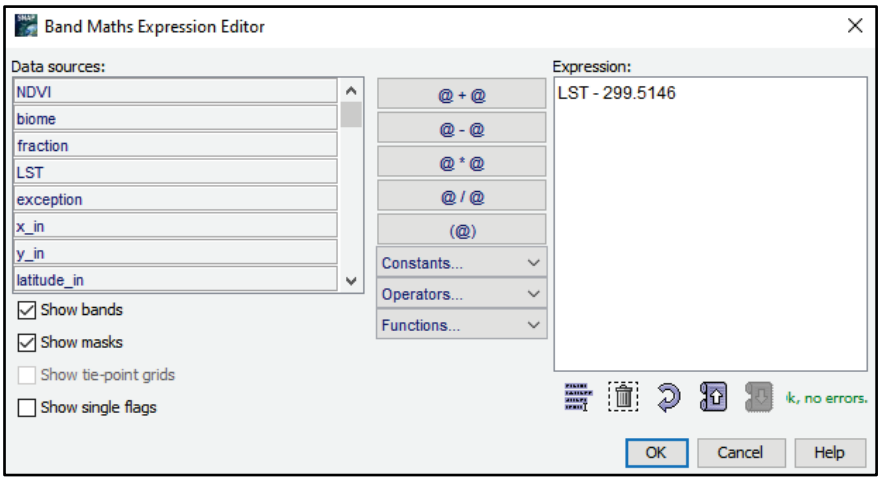

## 2.5. Creating the new band for UHI

In the next stage, the mean temperature of non-urbanised areas is subtracted from the LST measurements. We can use the Band Math

operator, for this purpose. Right click on the LST_20190724_night product and we select Band Math.




We change the band name to UHI_N, un-select Virtual and we click on the Edit Expression button. The result is stored as a separate UHI_N band, according to the expression: LST - 299.5146 (for night image).



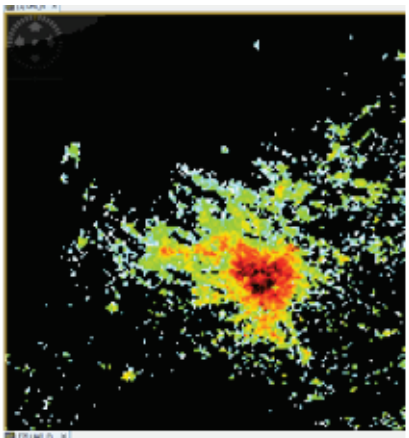

Then, we close all previous visualizations except for the latest created UHI_N band.

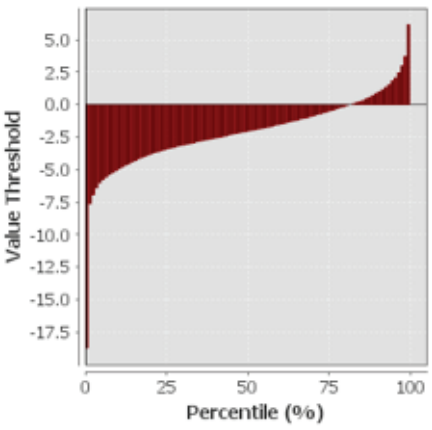
## 2.6. Comparison of day-night temperature changes

In the Colour Manipulation panel we select again the colour scale and also sets the temperature range for urbanized areas from 0 to 6. This range symbolises the temperature rise in degrees K for individual pixels in

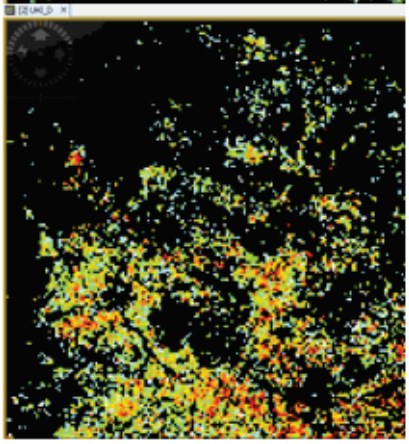
urbanized areas. Visible difference in temperature change between urbanized non-urban areas.

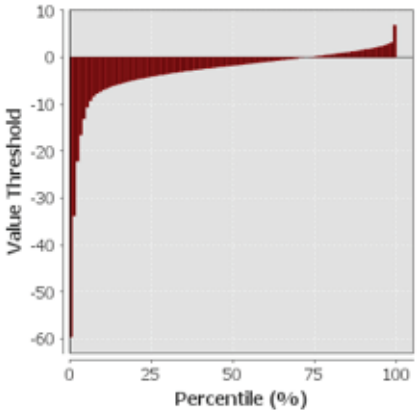
Night





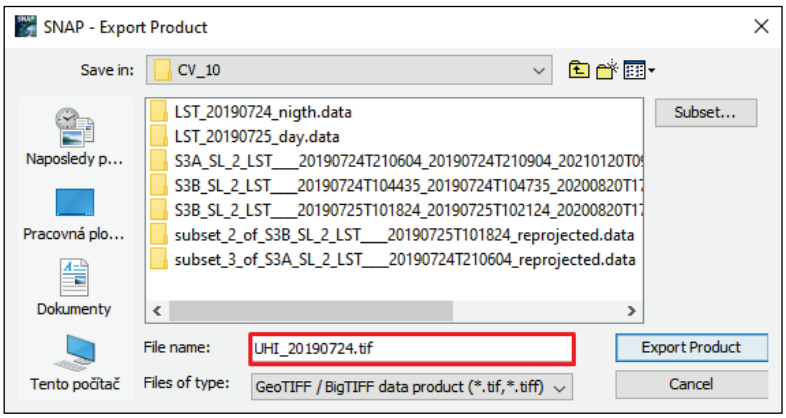

Day



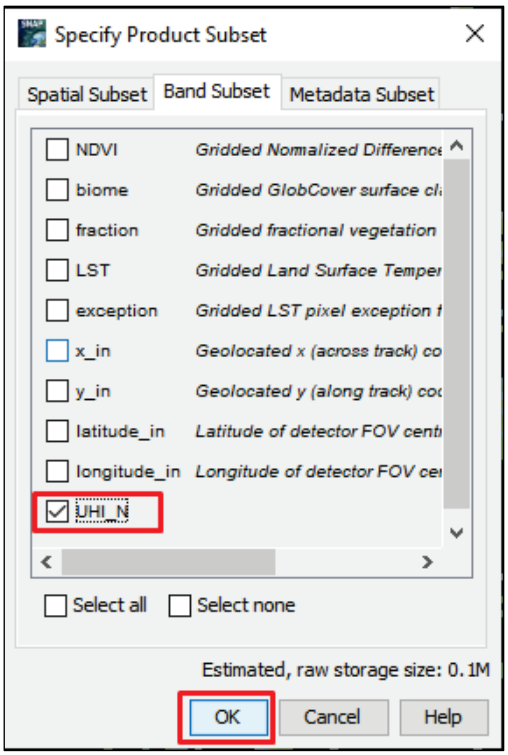



## 2.7. Data export

Once the result is ready, we will export final image as GeoTIFF file UHI_20190724.tif by means of File - Export – GeoTIFF.




During the export, the exported bands are filtered using the Subset - Band Subset option. Specifically, only the created UHI band will be used for export purposes. The export is performed for both day and night sensing period.

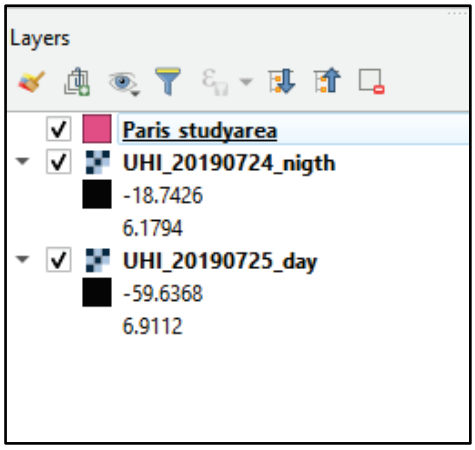



## 3 Results interpretation

Import data

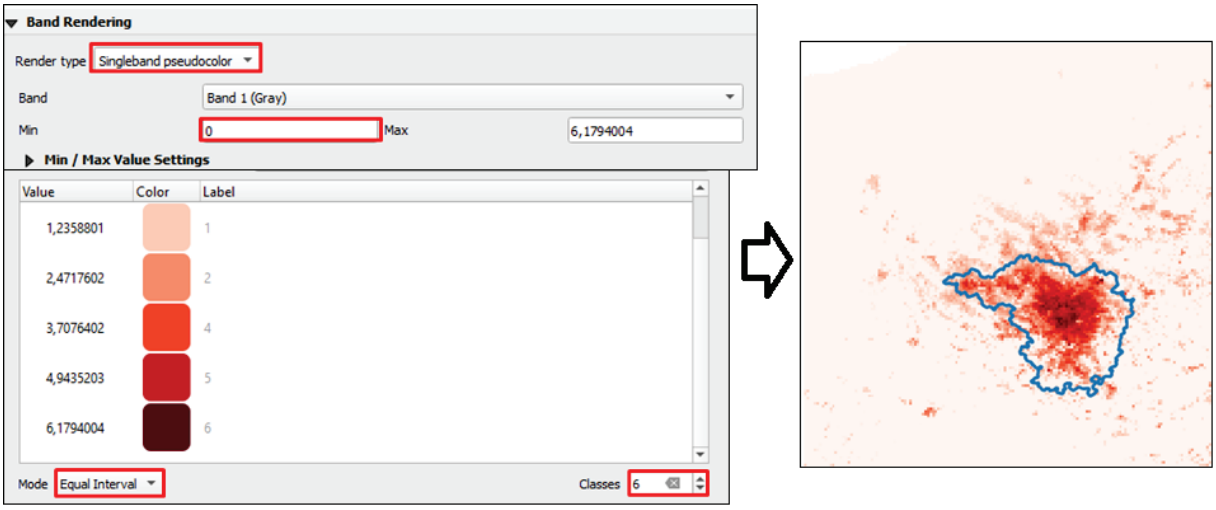
Firstly, we import the following into the panel Layers:

- UHI files in geotiff format (exported from SNAP)
- Administrative boundaries in .shp format (available on: earthworks.stanford.edu/catalog/stanford-rq053wf7492)




Editing image parameters and descriptive data

Secondly we modify the display palette type, number of classes (in terms of temperature rise), defining the numerical range, etc. All of these operations we perform on the image tab Properties in QGIS.

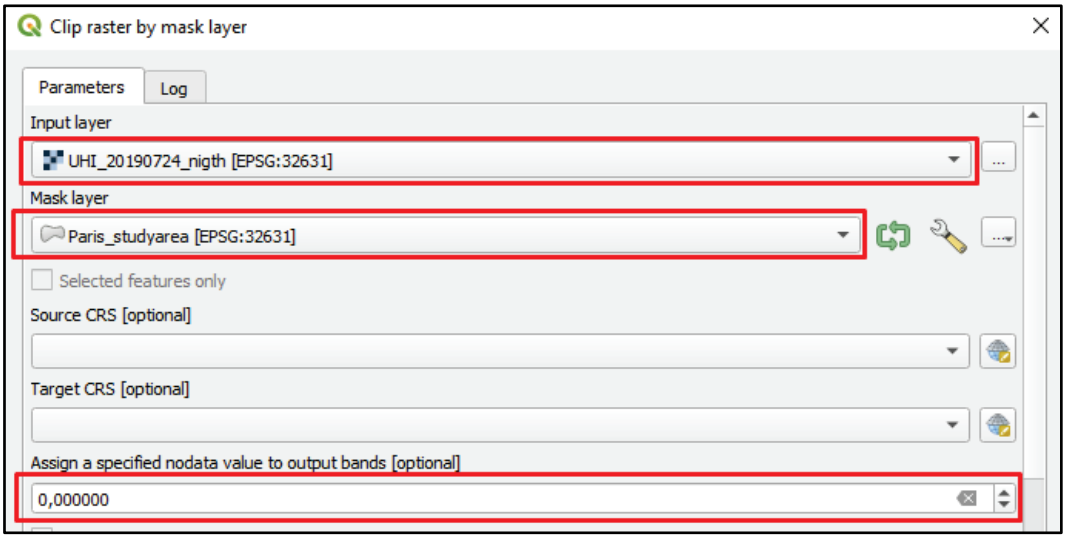



Add map background

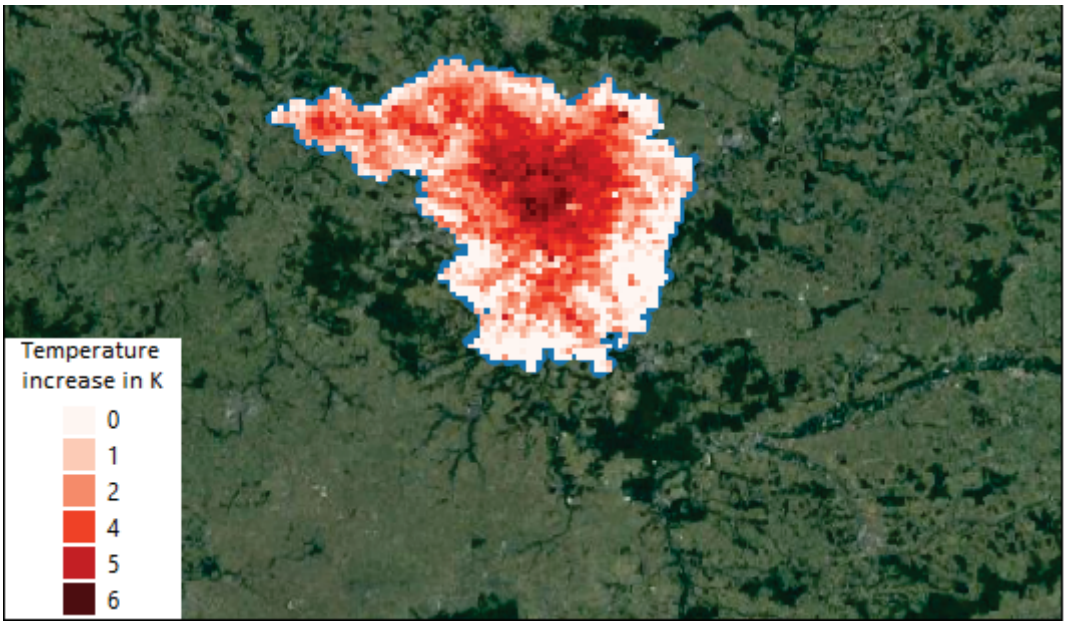
The next step is adding Google satellite map as the background map. We use the XYZ panel for adding a new connection. In the XYZ panel we paste basemap layer link for Google satellite maps. This link is available on the following URL address: https://www.google.cn/maps/vt?lyrs=s@189&gl=cn&x={x}&y={y}&z={z}.

Final results interpretation

The range of the final output (ROI) is adjusted using Raster - Extraction - Clip raster by mask layer according to the .shp file administrative boundaries of the city of Paris




The final map representation shows increasing of land surface temperature in Kelvins in the Paris study area.




THANK YOU FOR FOLLOWING THE EXERCISE!