EXERCISE 10 – TUTORIAL

Land surface temperature mapping using Sentinel-3 data using SNAP software

1 | Exercise outline
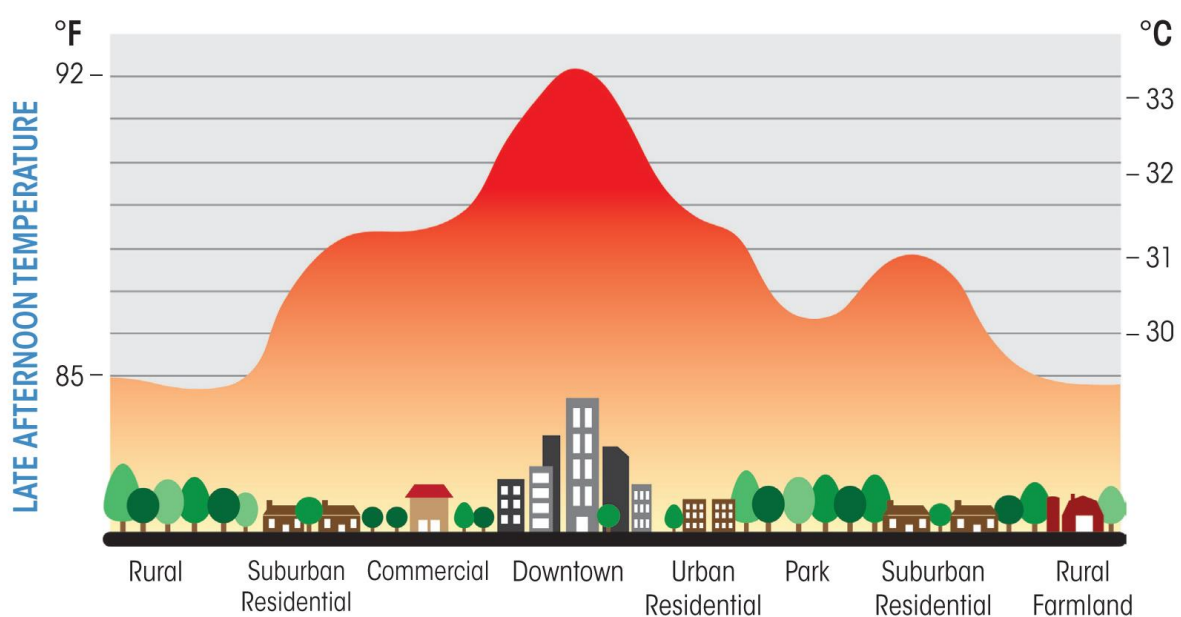
In this exercise, we will:

- learn about the phenomenon Urban Heat Island

- use Sentinel-3 LST product to analyse and classify surface temperature

- use land cover / land use band for extraction of land temperature

- extract the mean temperature by Pin placing tool and SNAP Statistics tool

- visualize the resulting Urban Heat Island map clipped on an interesting area

2 | Background

Urban heat islands are regions within cities that encounter higher temperatures compared to their surrounding areas. The presence of structures like buildings and roads, along with limited greenery, causes urbanized zones to absorb and release solar heat more efficiently than natural landscapes. This concentration of structures in urban areas leads to the formation of "islands" with higher temperatures, where daytime temperatures can be 1-7°F higher and nighttime temperatures approximately 2-5°F higher than those in the adjacent areas.

Urban areas, marked by high population and construction density, face challenges related to waste heat and Urban Heat Islands (UHIs). As cities expand vertically with skyscrapers, trapped heat from construction accumulates within UHIs. During nighttime, UHIs retain higher temperatures due to obstruction of upward heat movement by buildings and infrastructure, creating a warmer environment.

Furthermore, UHIs exhibit worse air and water quality compared to rural areas. The dense concentration of pollutants, originating from vehicles, industry, and human activities, results in lower air quality.

2.1 Study area and data used

In this exercise, we will analyse Sentinel-3B image acquired during June 2023 and downloaded from the Dataspace Copernicus Open Access Hub [@https://dataspace.copernicus.eu/].

Navigate to the area of Slovak republic, create an area of interest by clicking on the icon in the upper right corner of the map and draw a rectangle as indicated below.
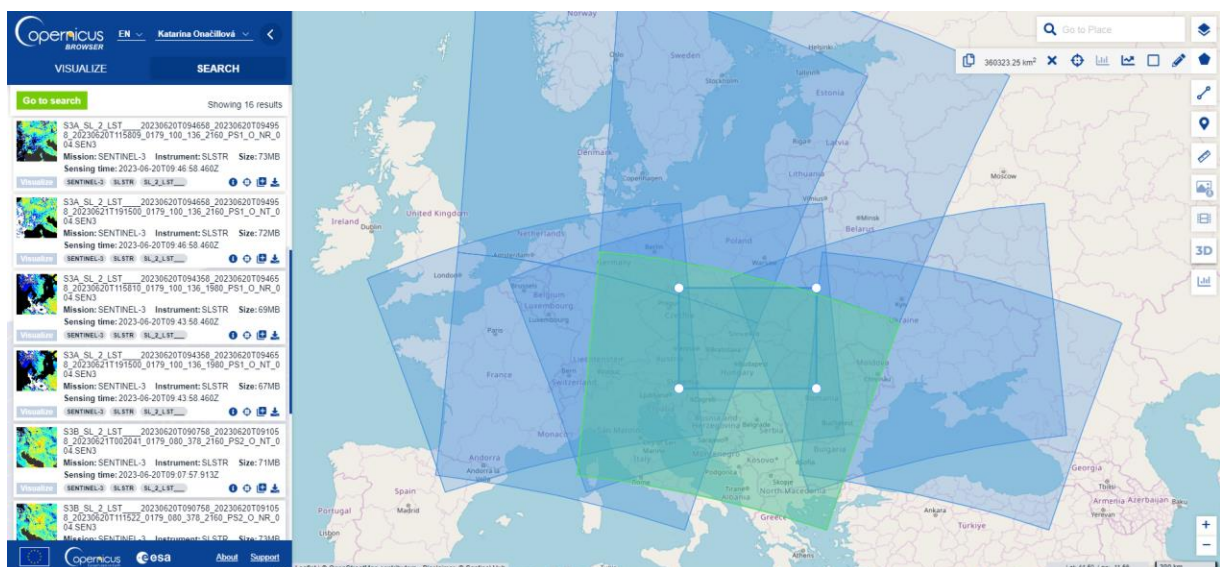
In the search menu on the left specify the following parameters and press the search button:
Data source: Sentinel-3 – SLSTR – Level-2 LST
Sensing period: From 2023/06/20 to 2023/06/20
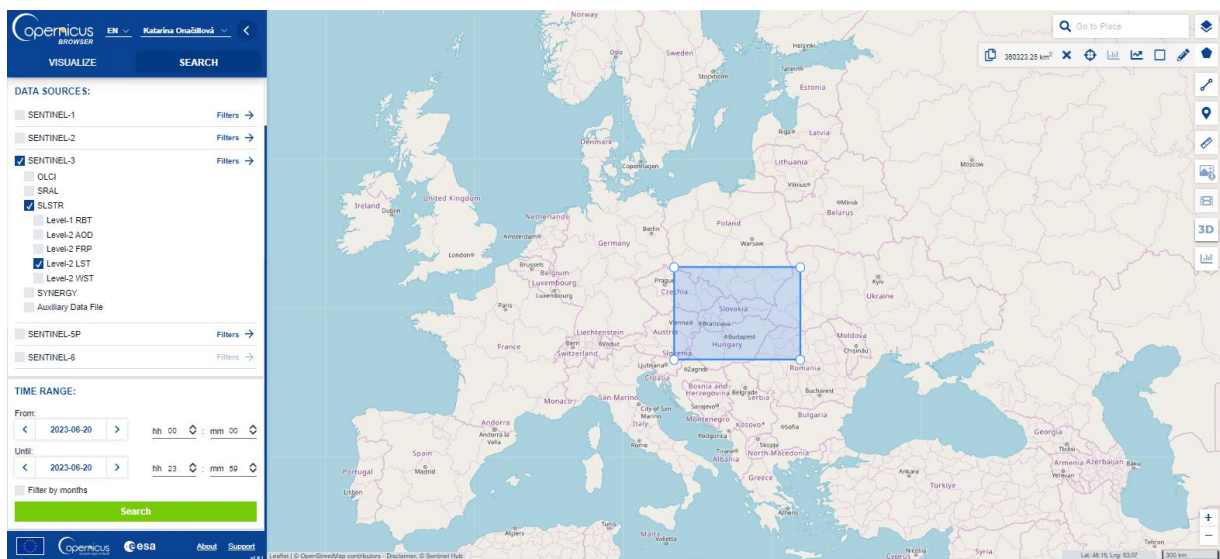
In our case, the search returns 16 results (day and night acquisitions). Search for those that cover the entire area of the Slovakia and download them (if needed).

Download the day product by clicking on the arrow icon. Note the different sensing times of the images:

S3B_SL_2_LST____20230620T090758_20230620T091058_20230621T0
02041_0179_080_378_2160_PS2_O_NT_004.SEN3 (day acquisiton)

Once downloaded, move it to your folder for this exercise and unzip it.

2.2. SNAP - Open and explore product

Open SNAP Desktop, click Open Product and navigate to the folder where you saved your downloaded products and open the day-time Sentinel-3 product from 2023-06-20:
S3B_SL_2_LST____20230620T090758_20230620T091058_20230621T0
02041_0179_080_378_2160_PS2_O_NT_004.SEN3

Open the folder and select the file xfdumanifest.xml. Then, click OK.

In the Product Explorer, expand the product by clicking in the left arrow. Expand now the Bands folder and double click on the band LST to visualize it.
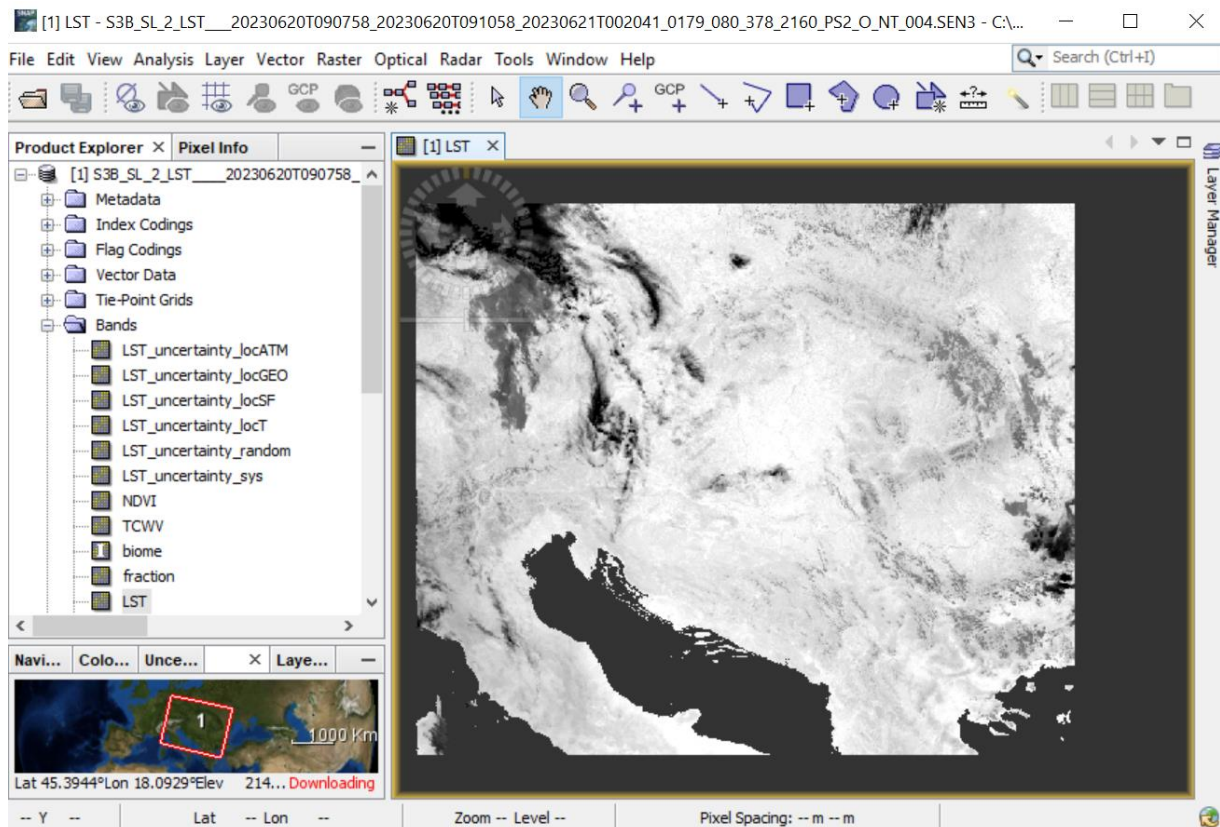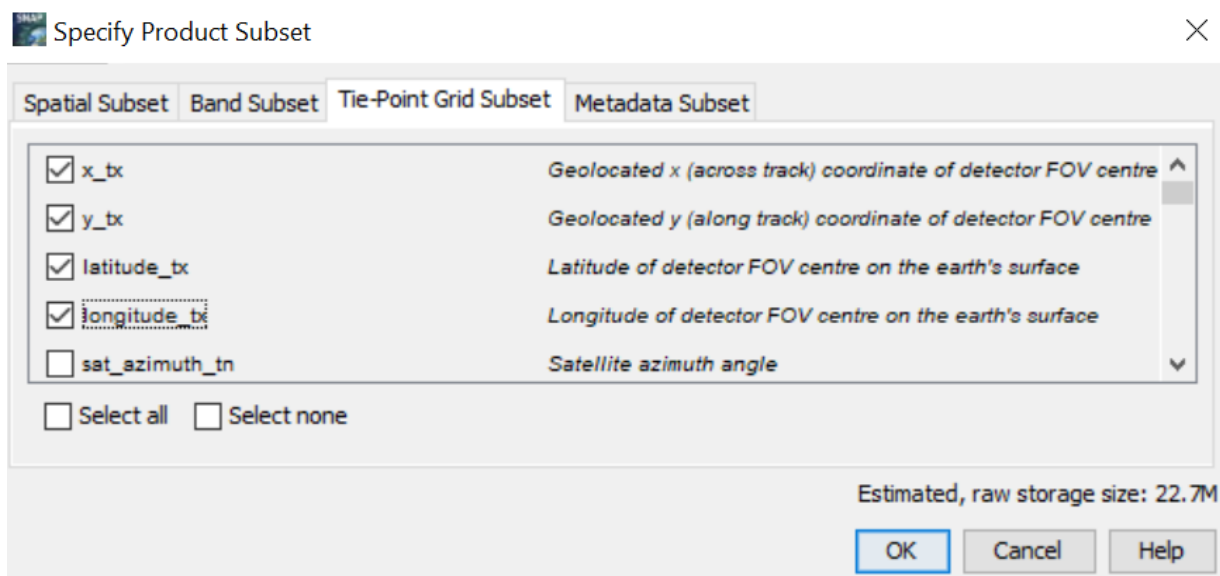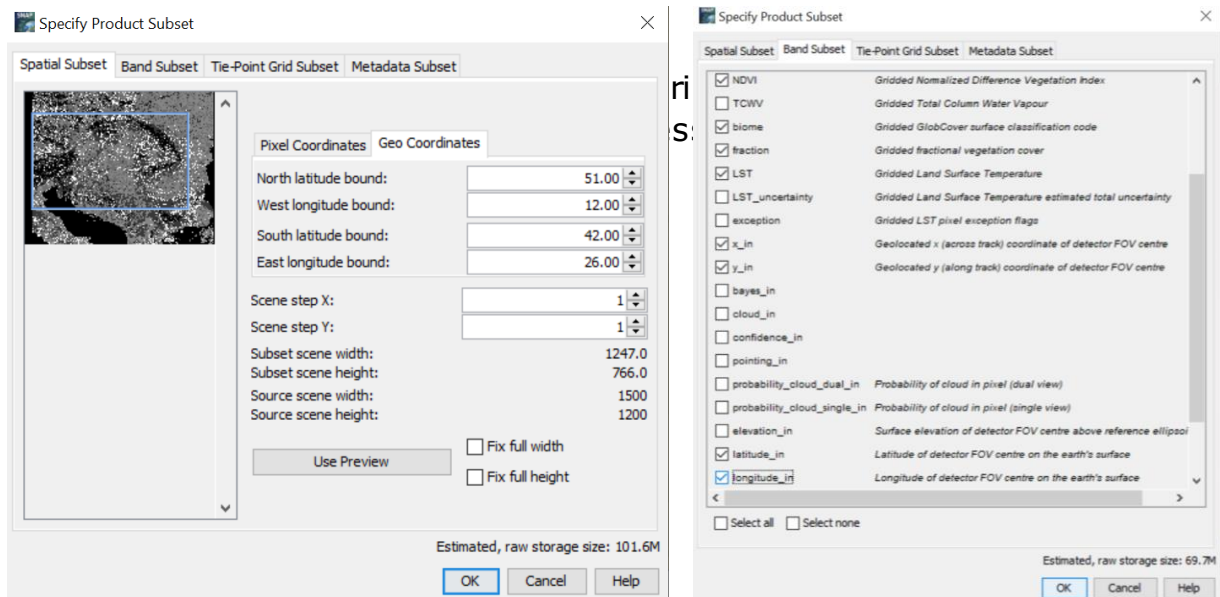
2.3. Subset

The initial phase of the methodology involves reducing the original size and number of bands in the image. To accomplish this, choose the Sentinel-3 SLSTR product in the Product Explorer, then proceed to Raster -> Subset. Within the Spatial Subset tab, select Geo Coordinates and input the specified values:

North latitude bound: 51.00
West longitude bound: 12.00
South latitude bound: 42.00
East longitude bound: 26.00

In the Band Subset tab, opt for the bands NDVI, biome, fraction, LST, x_in, y_in, latitude_in, and longitude_in. In the Tie-Point Grid Subset tab, choose only the bands x_tx, y_tx, latitude_tx, and longitude_tx. Then, click OK (responding with No to the pop-up flag dataset window).

Upon completion, the subset product will be visible in the Product Explorer. It is essential to save it by right-clicking on it and selecting Save Product. Confirm the saving process by clicking YES in the ensuing pop-up window.

2.4 Reprojection

Proceed to reproject the Sentinel-3 SLSTR product using an appropriate map projection. Navigate to Raster -> Geometric -> Reprojection.

In the I/O Parameters tab, ensure that you choose the subset product as the input. Modify the output name to e.g. "S3B_LST_20230620_day_reprojected" and set/confirm that the output directory.

Within the Reprojection Parameters tab, access the Projection drop-down menu, and opt for UTM/WGS 84 (Automatic). Subsequently, click on Run.
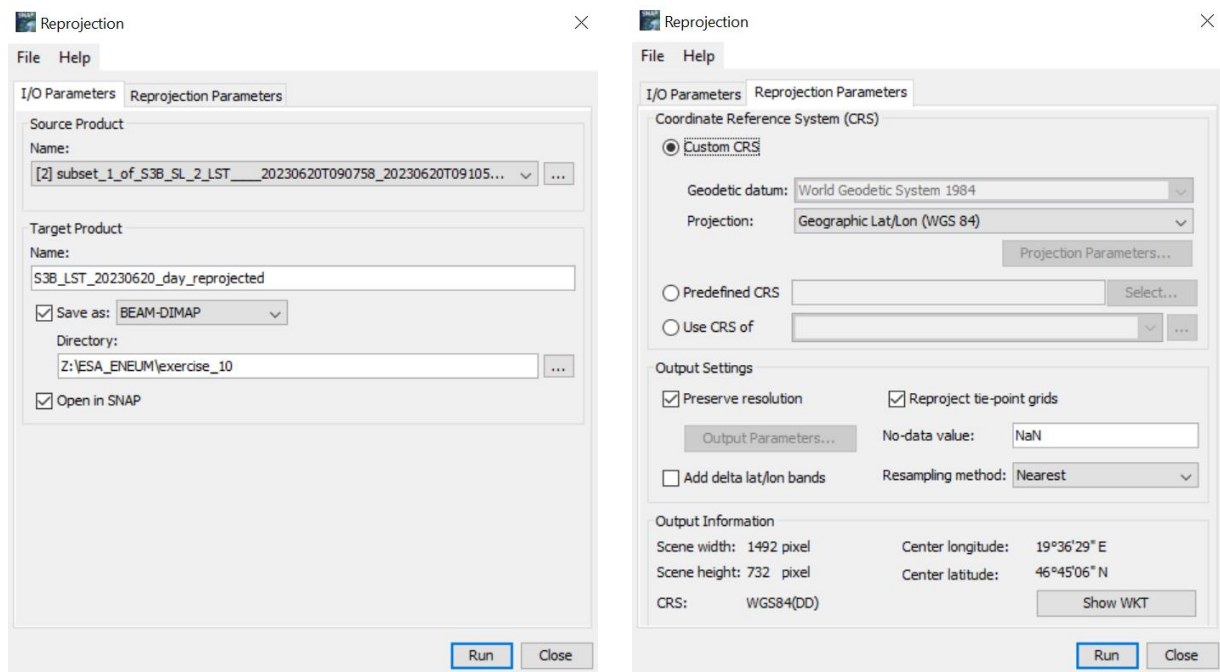
Within the Product Explorer, expand the reprojected product by selecting the left arrow. Expand the Bands folder, and double-click on the LST band to view it.

Access the Colour Manipulation tab, choose Basic as the Editor, and click on the e.g. „derived from spectrum_large" color ramp
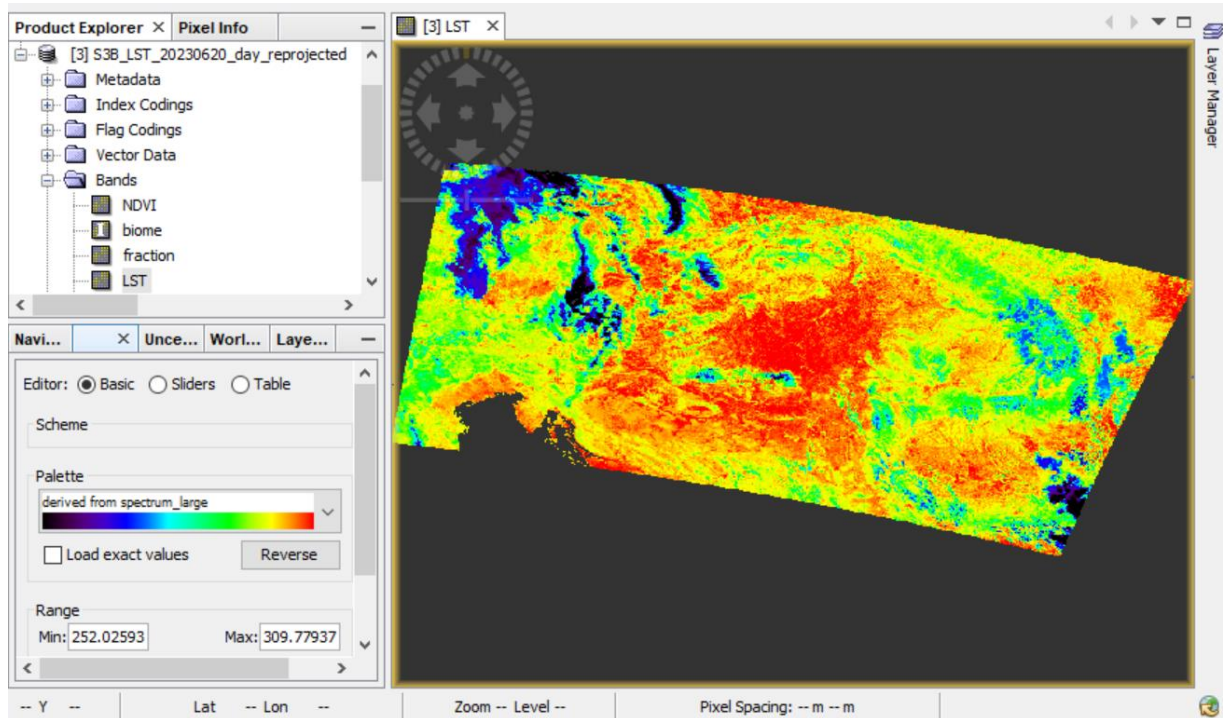

2.5 Clip by mask

Now let´s focus on the smaller area of interest, e.g. territory of the Slovak Republic. Choose the last Sentinel-3 reprojected product in the Product Explorer, then proceed to File – Import – Vector data – ESRI shapefile and open „SR_boundaries.shp" file that you have in the folder for this exercise. Once imported, this layer should appear within the product Vector data and also on the visualized LST image.
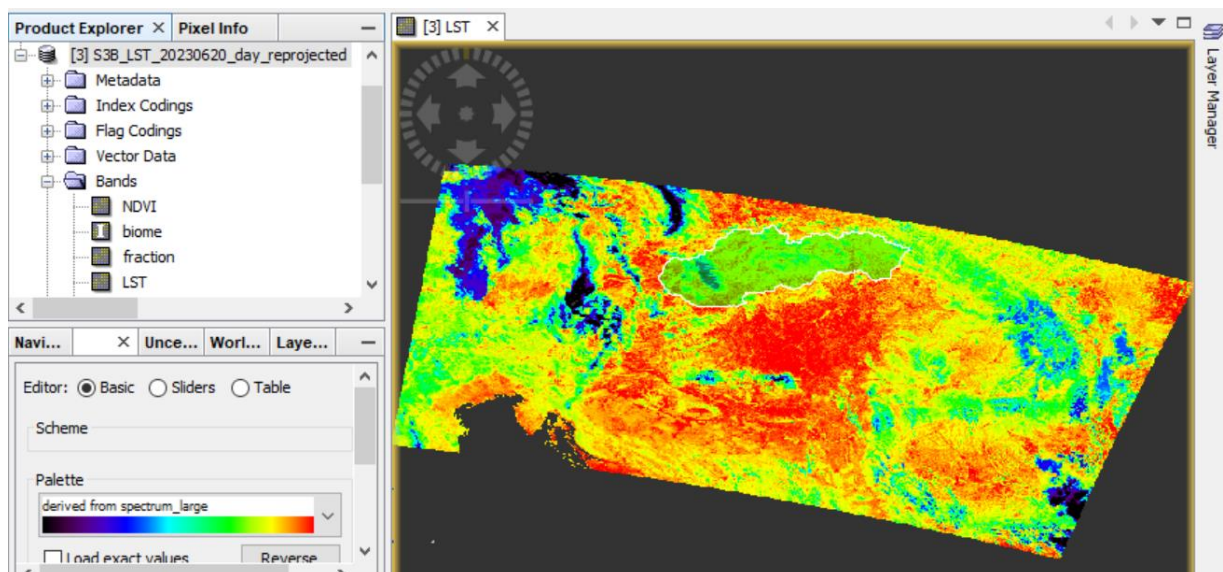
Now navigate to Raster – Masks – Land/Sea Mask. In the I/O Parameters tab you can rename the output target product to e.g. "S3B_LST_20230620_day_reprojected_msk" and set the output directory. In the Processing Parameters select the option „Use Vector as Mask" and „SR_boundaries" layer according to which the product will be clipped.
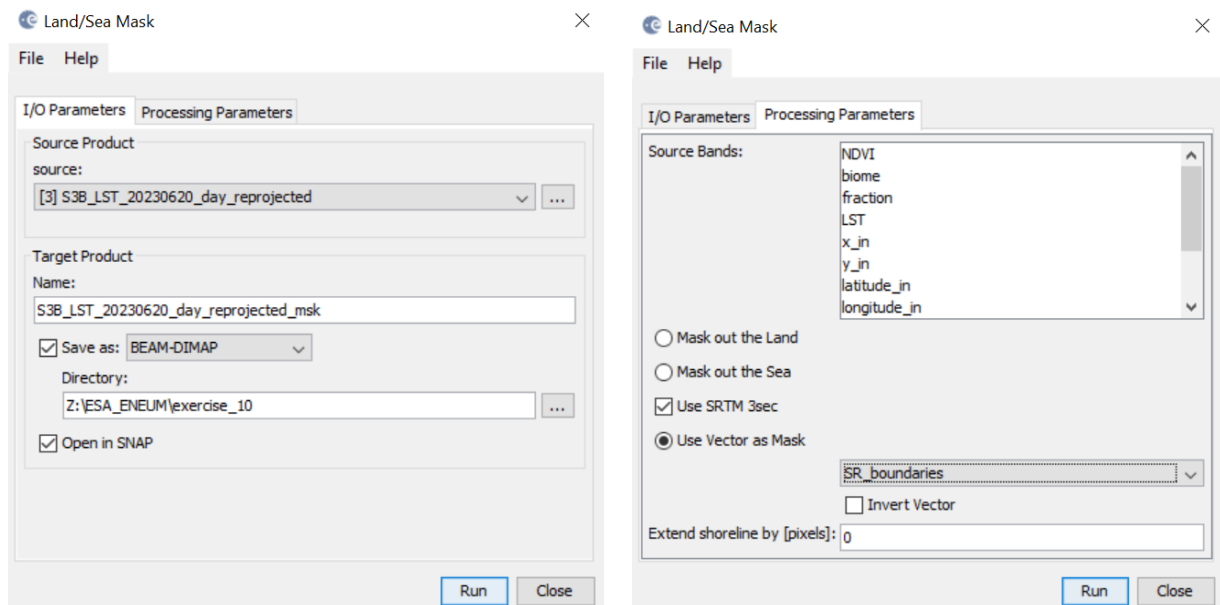
The resulted clipped product of the area of the Slovak Republic can be reprojected to lacal coordinate system using an appropriate map projection. Navigate to Raster -> Geometric -> Reprojection.
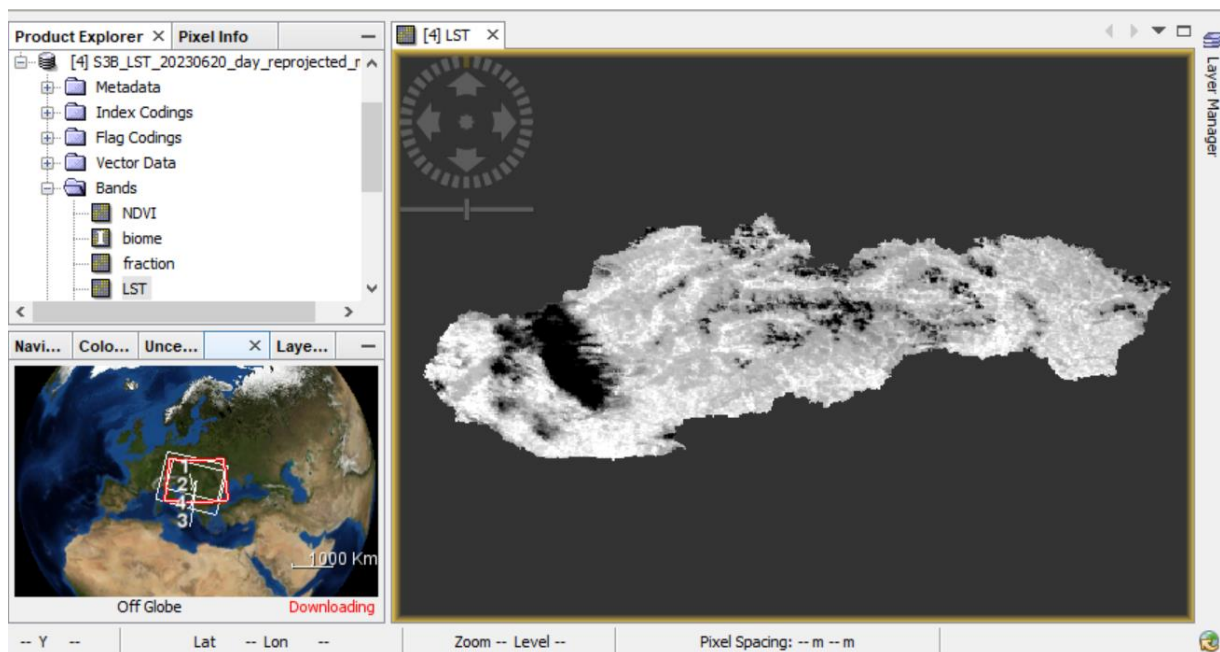
- In the I/O Parameters tab, ensure that you choose the last clipped product as the input. Modify the output name to e.g. "S3B_LST_20230620_day_reprojected_msk_Krovak" and set/confirm that the output directory.
- Within the Reprojection Parameters, access the Projection drop-down menu, and opt for Custom CRS - Krovak. Subsequently, click on Run.
- Within the Product Explorer, expand the final reprojected product by selecting the left arrow. Expand the Bands folder, and double-click on the LST band to view it. Access the Colour Manipulation tab, and choose e.g. „derived from spectrum_large" color ramp
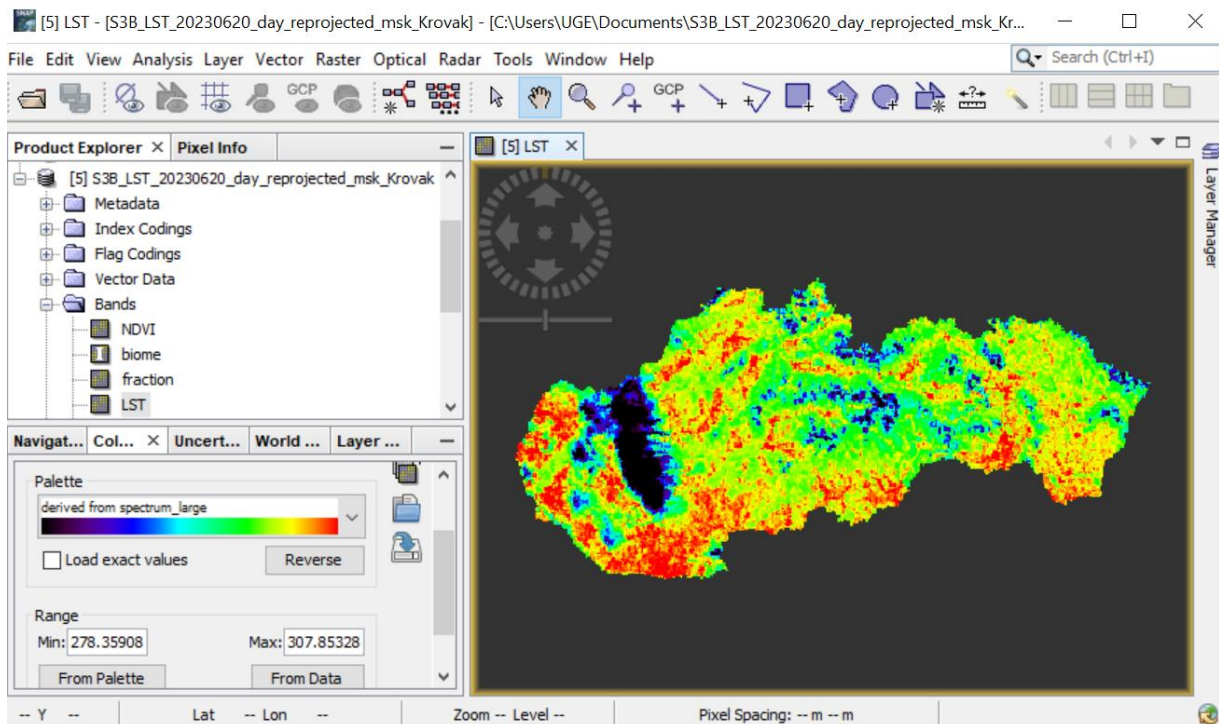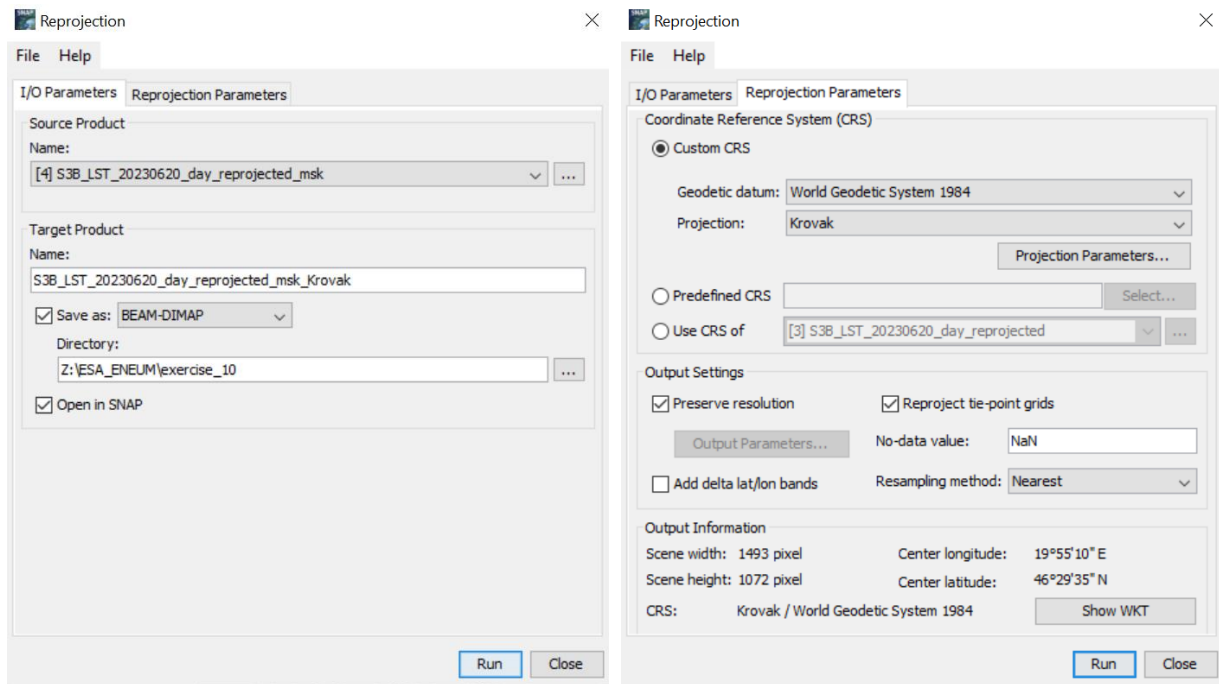
Explore the temperatures (in Kelvins). Click on the Pixel info tab and move the mouse over the images to analyse pixel values.
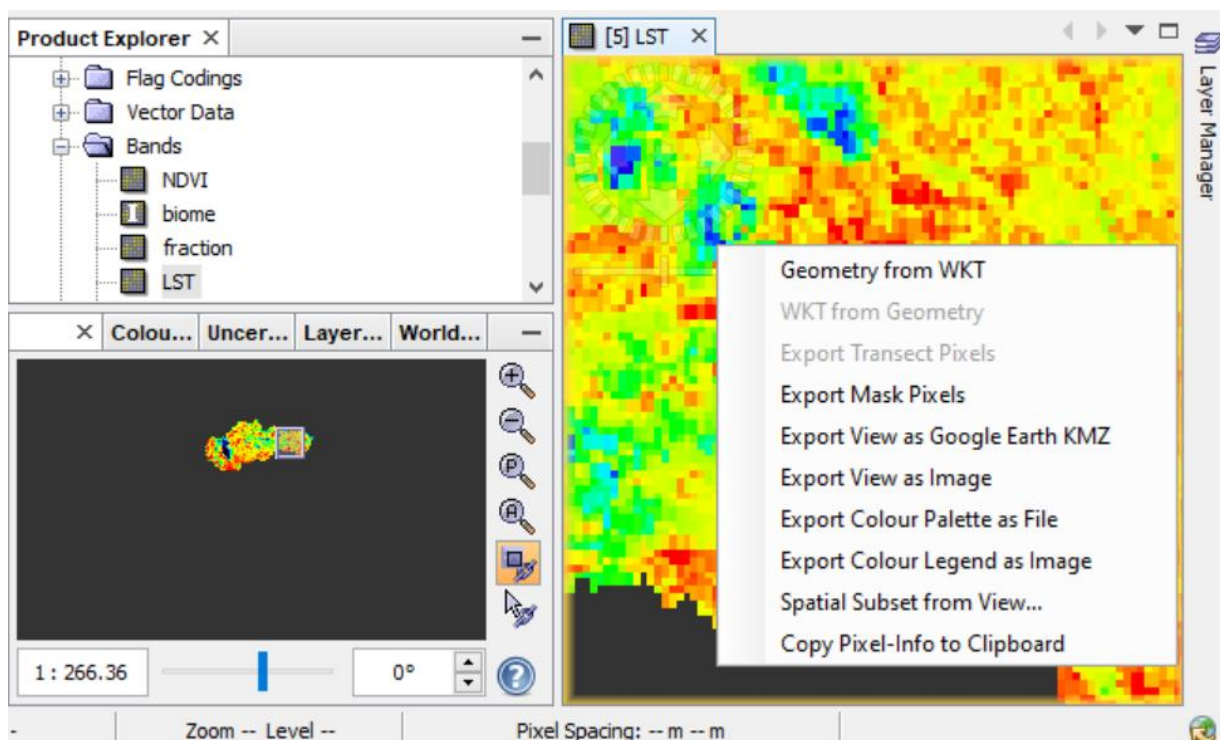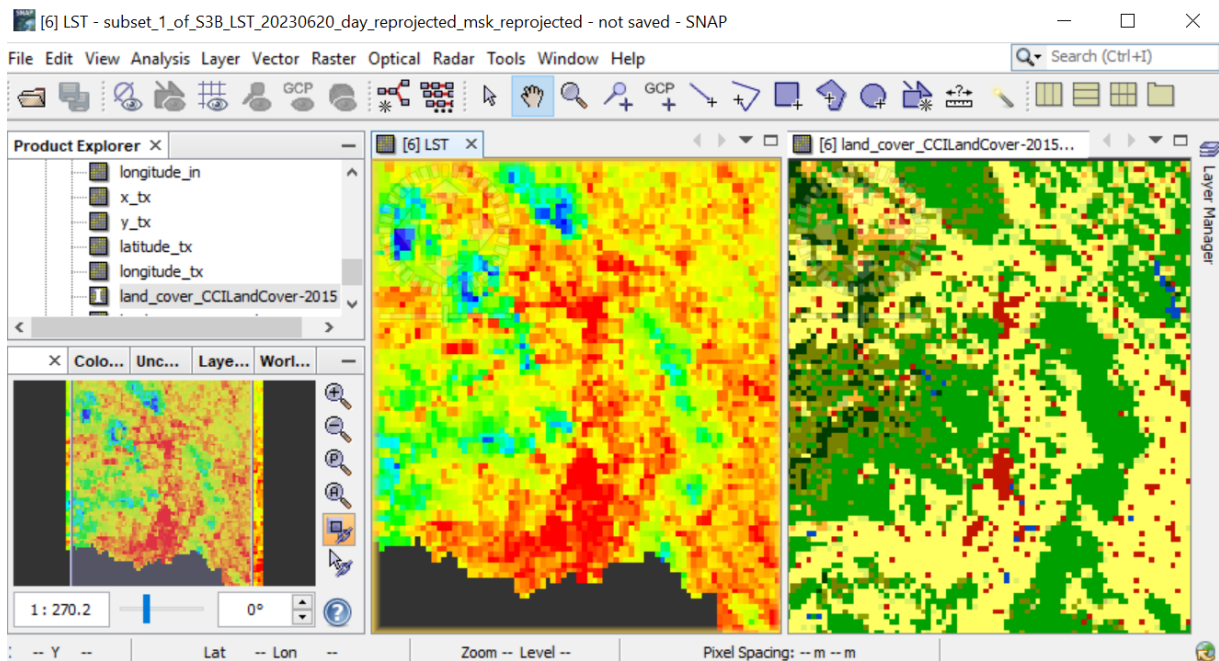

2.6 Add Land Cover Band

After comparing the temperature values (in Kelvin) during the day and night acquisitions, proceed to close the day product. In order to better identify the influence of urbanised areas on temperature, subtract the average temperature of non-urban areas near Košice.

To facilitate this, create smaller subset of day image – zoom into the vicinity of the Košice city, estern Slovakia – right click on the view – Spatial Subset from View... OK.

Then, open the LST layer from Bands of newly created subset and add a land cover band to distinguish various land cover and land use types. To do this, right-click on the day product, choose "Add Land Cover Band," navigate to CCILandCover-2015 in the menu, and click OK.
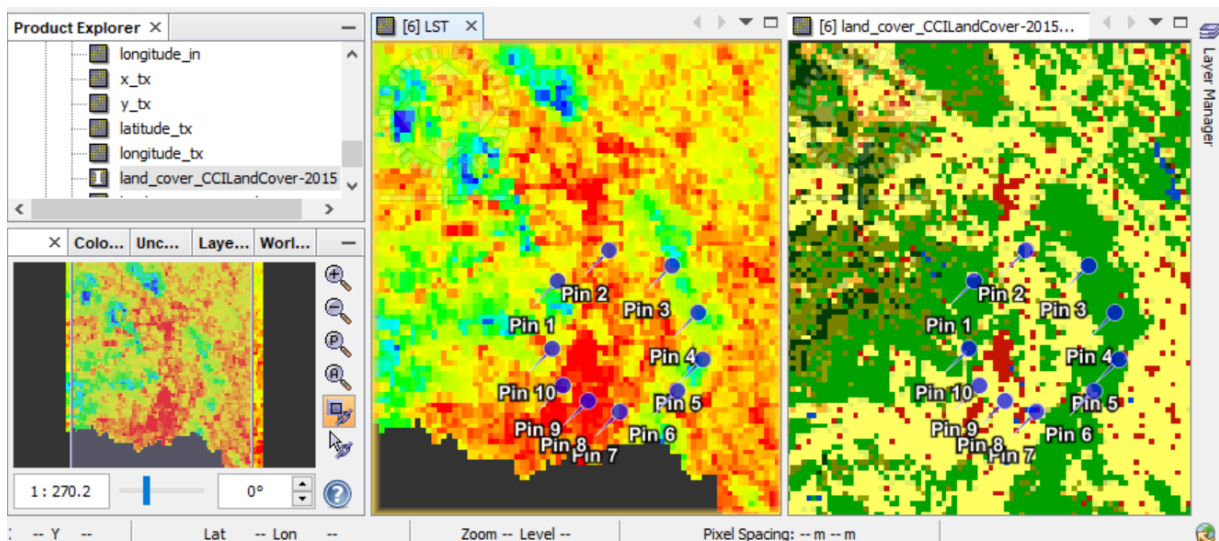
2.7 Mean temperature

After adding the land cover band, the subsequent action involves calculating the average temperature in the vicinity of Košice city by utilizing specific pixel values pinpointed with the Pin tool in SNAP. The ideal quantity is around 10 control points. Using these control points, it becomes feasible to calculate an average temperature value.


After creating the pins in the image, we can calculate the average value for the pixels identified by these pins using the Statistics tool in SNAP.

Close the land cover visualization and navigate to the Analysis -> Statistics. Choose the option „Use ROI Mask(s)" and select "pins." Lastly, click the refresh button.

From the panel on the right side, we can obtain the mean temperature value (304.2688) for day image by referencing the pins recently inserted into our image.
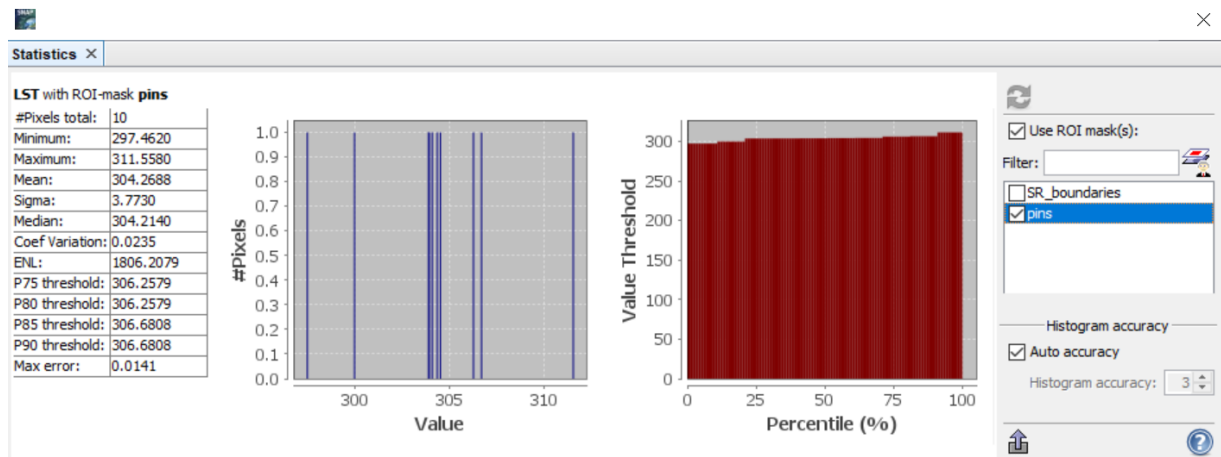

We can proceed to utilize the Band Math operator to subtract this value from the LST measurements. Right-click on the LST_20180802_night product, choose Band Math, modify the name to UHI_night, uncheck Virtual, and dick the Edit Expression button. Copy and paste the provided expression, then click OK:

Close all previous visualizations except for the recently generated UHI_day_20230620band. Navigate to the Colour Manipulation tab, choose Basic as the editor, and select the palette. Then, click on the tab From Data to see the range of the final night UHI. Adjust the Min and Max values to ranges from 0 to the last value of the dataset (in this case 12.0).
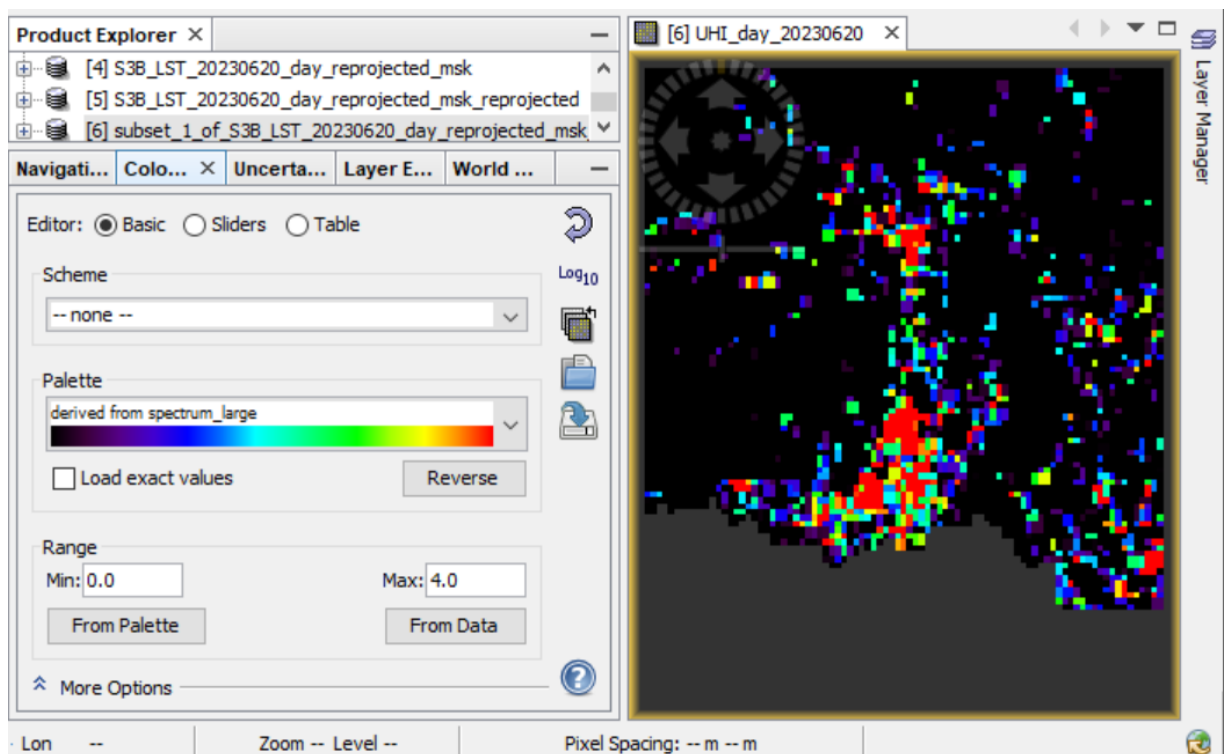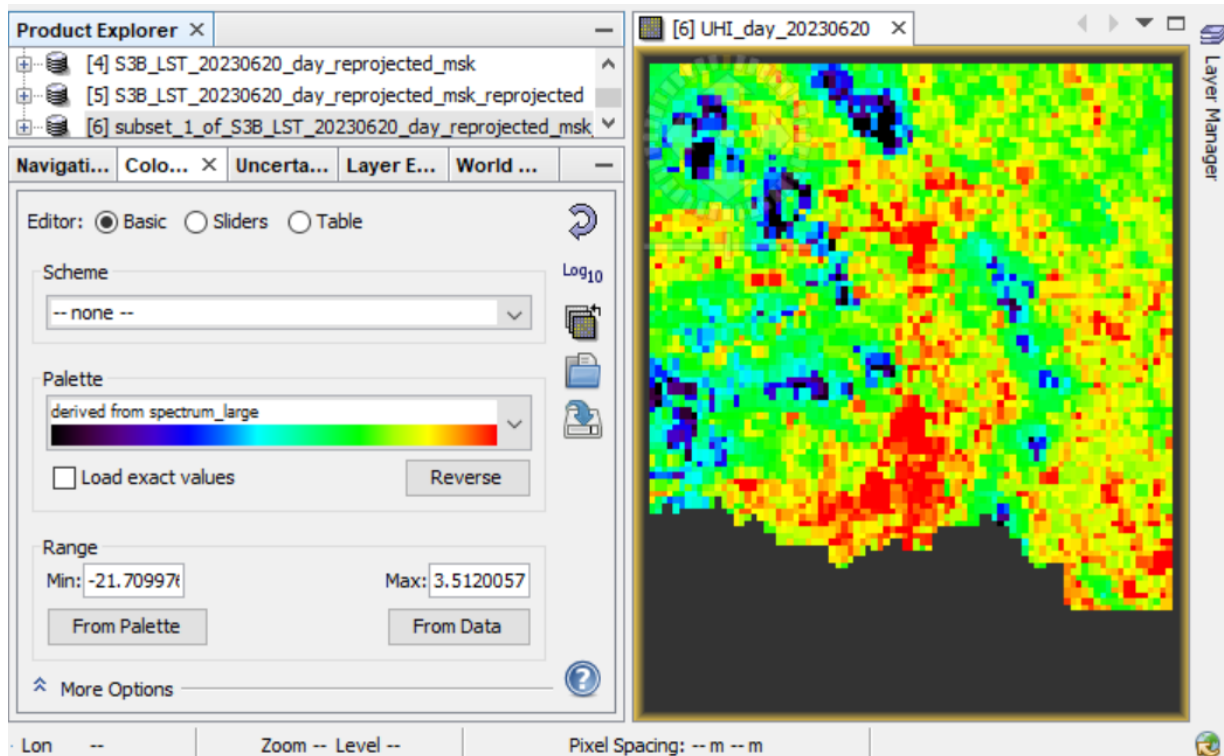
2.8 Data export to QGIS

Once the result is ready, we will export it as GeoTIFF and open it in QGIS. For that, data must be again reprojected to Geographic Lat/Lon. Then, go to File -> Export -> GeoTIFF. Click on the Subset tab, and in the Band Subset menu select only the band UHI_day_20230620. Save the file with the name UHI_night_20230620.tif in the following path and click Export Product:
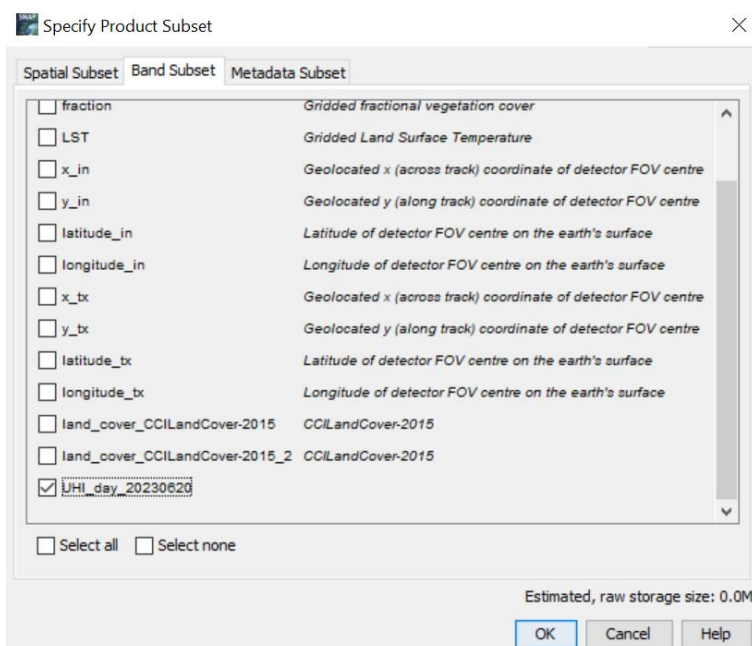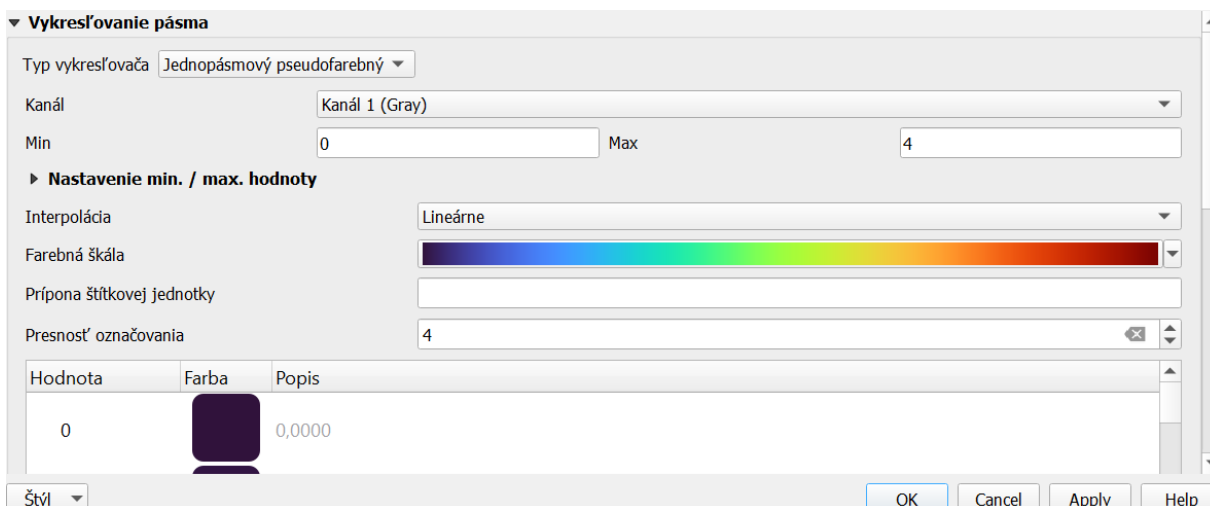

Data import to QGIS

Once the images are processed in SNAP, we will visualize the results in QGIS. Minimize SNAP and open QGIS.

Import the subset_UHI_day_202306 into the panel Layers

Edit image parameters of subset_UHI_night_202306 – Navigate to Properties of this image and change the color palette. Set the Min/Max values for the night UHI similar like in the SNAP (0-12).

Now navigate to Web – OpenLayers plugin – Bing maps and add e.g. Bing aerial with labels. Place the layer UHI_day_20230620 above the layer of Bing map. Set transparency to the UHI_day_20230620 layer (Properties – Transparency).

Finally, explore the Urban Heat Island in the vicinity of Košice city and land use/cover that affects it.
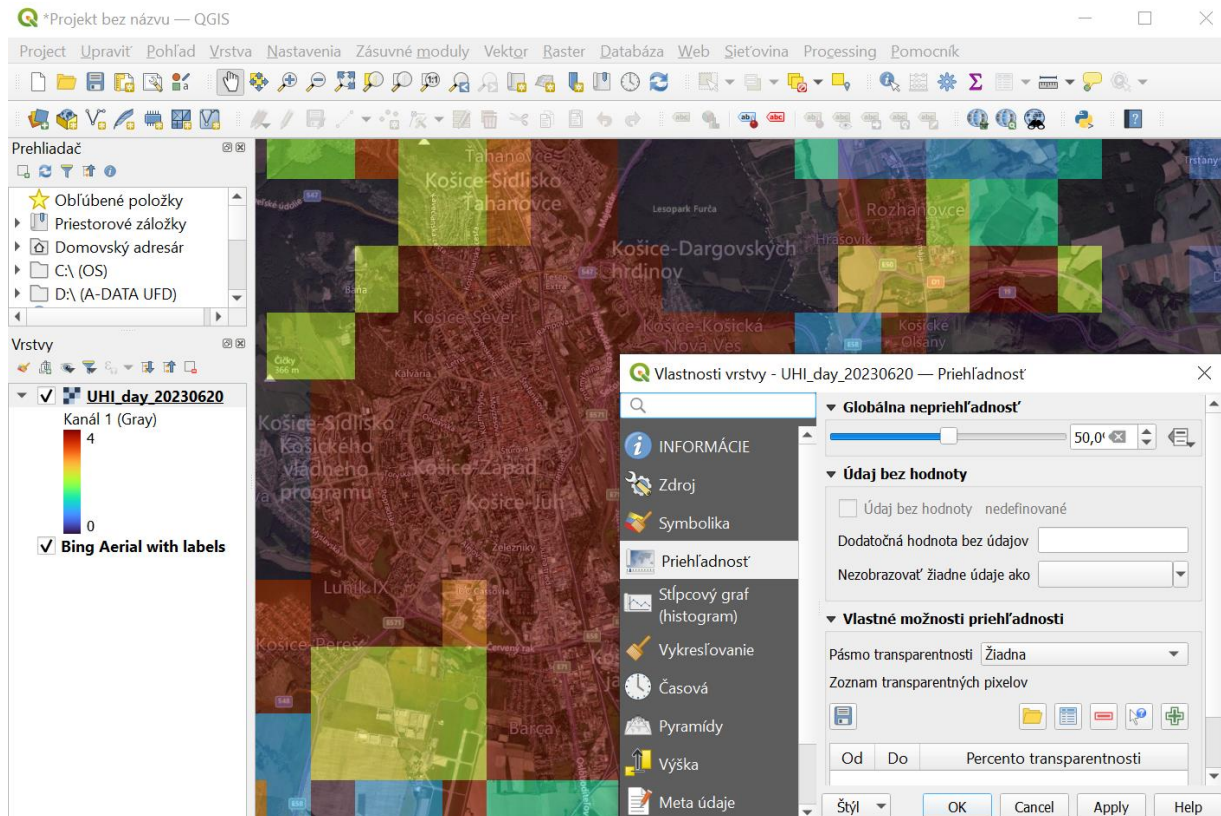
THANK YOU FOR FOLLOWING THE EXERCISE!