

TRAINING KIT – LAND09

URBAN HEAT ISLAND WITH SENTINEL-3 Case Study: London, 2018









Research and User Support for Sentinel Core Products

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1 Introduction to RUS

The Research and User Support for Sentinel core products (RUS) service provides a free and open scalable platform in a powerful computing environment, hosting a suite of open source toolboxes pre-installed on virtual machines, to handle and process data derived from the Copernicus Sentinel satellites constellation.

In this tutorial, we will employ RUS to monitor the urban heat island phenomenon in London (UK) using Sentinel-3 SLSTR sensor as source of information.

2 Urban Heat Island – background



Currently, more than half of the world's population live in urban areas and this number is still rapidly increasing. Since settlements represent the centers of human activity, the environmental, economic, political and cultural impacts of urbanization are far-reaching. They include negative aspects like the loss of natural habitats, biodiversity and fertile soils, climate impacts, waste, pollution, etc., making urbanization one of the most pressing global challenges.

The Urban Heat Island (UHI) phenomenon is one example of the effect of urban areas in the local climate. The effect mainly consists of the heating of urban zones in comparison to its non-urbanized surroundings. The atmospheric air temperature of densely urbanized areas is higher than the one of the nearby rural areas. Its relevance usually appears during the night because of the release of energy that has been stored by built-up surfaces during the day. Among the local impacts and negative effects of the UHI phenomenon, we can highlight thermal stress & deaths, higher energy consumption (due to air-conditioning), atmospheric chemistry (0_3 emissions from energy consumptions), increased water demand amongst others.

3 Training

Approximate duration of this training session is one hour.

The Training Code for this tutorial is LAND09. If you wish to practice the exercise described below within the RUS Virtual Environment, register on the RUS portal and open a User Service request from Your RUS service > Your dashboard.

3.1 Data used

- 2 Sentinel-3A images acquired on 2nd August 2018 [downloadable at <u>https://scihub.copernicus.eu/</u>
- Pre-processed data stored locally
 @/shared/Training/LAND09_UrbanHeatIsland_London/AuxData/

3.2 Software in RUS environment

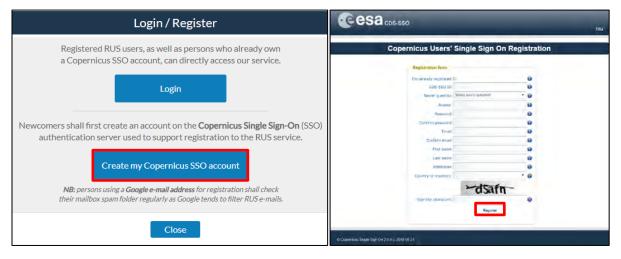
Internet browser, SNAP + S3 Toolbox

4 Register to RUS Copernicus

To repeat the exercise using a RUS Copernicus Virtual Machine (VM), you will first have to register as a RUS user. For that, go to the RUS Copernicus website (<u>www.rus-copernicus.eu</u>) and click on *Login/Register* in the upper right corner.

CORRUS Research and User Support	
The RUS Service * The RUS Offer * The RUS Library * The RUS Community *	
	Senth
	News from RUS
	One year on!
	Copernicus Info Session - Reykjavik - 19 September 2018
To a series of the series of t	SPIE Remote Sensing 2018 – Berlin (Germany) – 11-12 September 2018
	SIWI World Water Week 2018 – Stockholm – 26-31 August 2018
	MedRIN Kick-off Meeting - Chania - 13 & 14 July 2018
	RUS Webinar – Special edition "AskRUS – Sentinel-1" – 12 July 2018
Welcome to Research and User Support	RUS Training Session – Valencia – 22 July 2018
	IGARSS 2018 - Valencia - 22-27 July 2018
Welcome to the Copernicus Research and User Support (RUS) Service portal!	The RUS agenda
The RUS Service is the "New Expert Service for Sentinel Users" funded by the European Commission,	Conferences & Workshops

Select the option *Create my Copernicus SSO account* and then fill in ALL the fields on the Copernicus Users' Single Sign On Registration. Click *Register*.



Within a few minutes you will receive an e-mail with activation link. Follow the instructions in the email to activate your account.

You can now return to <u>https://rus-copernicus.eu/</u>, click on *Login/Register*, choose *Login* and enter your chosen credentials.

Credentials			
CDS-SSO ID Password Max Idle Time Max Session Time	half a day Until browser close Login Reset	Y Y	0000
	CDS-SSO ID Password Max Idle Time	CDS-SSO ID Password Max Idle Time half a day Max Session Time Until browser close	CDS-SSO ID Password Max Idle Time half a day Max Session Time Until browser close

Upon your first login you will need to enter some details. You must fill all the fields.

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	The RUS Service * The RUS C		o subscribe for a new RUS account?	Í		
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		Select one or more items Institution type Phone number Italy (IT):	newsletter conference social media other Select one item + 39		son - Poland - 6, P 10,& 13 Nov 2028 nm - Foulonse - 26 5 27 Oct. 2018 18	
	Ingentified by 12 Bound & Int Olive European	Title	Select one item Subscribe Cancel	~ 	💓 🧰 🛃	

5 Request a RUS Copernicus Virtual Machine

Once you are registered as a RUS user, you can request a RUS Virtual Machine to repeat this exercise or work on your own projects using Copernicus data. For that, log in and click on *Your RUS Service* \rightarrow *Your Dashboard*.

CORRUS Research and User Support	~9 # %	Hello, Miguel
The RUS Service The RUS Offer The RUS Library The RUS C	Community Vigit Your RUS serv Vour profile Vour dashboard Vour training	You are here: Home > Your RUS service
 This section gathers pages related to your RUS services: Your profile: displays your personal information linked to your ESA SSO a Your dashboard: Illows you to access your private dashboard, Your training: allows you to register to a training session you have been in 	and RUS accounts,	 News from RUS One year on! Copernicus Info Session - Reykjavik - 19 September 2018 SPIE Remote Sensing 2018 - Berlin (Germany) - 11-12 September 2018 SIWI World Water Week 2018 - Stockholm - 26-31 August 2018 MedRIN Kick-off Meeting - Chania - 13 & 14 July 2018 RUS Webinar - Special edition "AskRUS - Sentinel-1" - 12 July 2018
		RUS Training Session - Valencia - 22 July 2018 IGARSS 2018 - Valencia - 22-27 July 2018

Click on *Request a new User Service* to request your RUS Virtual Machine. Complete the form so that the appropriate cloud environment can be assigned according to your needs.

CORRUS Research and User Support	
The RUS Service * The RUS Offer * The RUS Library * The RUS Community	Y▼ ^{QpF} Your RUS service ▼
	You are here: Home > Your RUS service > Your dashboard
Your dashboard	
Request a new User Service	Chat with Support Desk.
Copyright © 2017 Research and User Support	Contact Us Terms and conditions Glossary Acronyms FAQ

If you want to repeat this tutorial (or any previous one) select the one(s) of your interest in the appropriate field.

Step 1/3 Your experience		
Please help us learn more information will be stored in	e about your background by answering a few que nyour User Profile.	stions, Ti
How many years of experience	e in Remote Sensing do you have?	
Choose one Item		
Have you already downloaded	Copernicus data via the Copernicus Open access hubs?	
Yes		
© No		
Have you already handled/pro	ocessed Copernicus data?	
W Yes		
O No		
Do you wish to practice a tutor (hold down CTRL key for multi	rial exercise shown in a RUS webinar? If yes, please select ye iple selections).	our choice
HAZA01 - Flood Mapping in N		
HAZA02 - Burned Area Mapp HYDR01 - Water Bodies Map		- 1
LAND01 - Crop Mapping in Se	eville	
LAND04 - Land Monitoring in		
OCEA01 - Ship Detection in G	Sulf of Trieste	
If you wish to request another	tutorial exercise that doesn't appear in the above list, pleas	e type here
	ou can request multiple tutorial exercises.	

Complete the remaining steps, check the terms and conditions of the RUS Service and submit your request once you are finished.

This is a collection of information selected	d across the USR forms.	
You can go back and edit this information	if necessary.	
General information on your request:		
Years of experience in Remote Sensing	5-10 years	
Downloaded Copernicus data?	1	
Handled/processed Copernicus data?	1	
Webinar codes	HAZA02, LAND04	
About your RUS project:		
Thematicarea	Cryosphere (ice and snow)	
Operations to perform on RUS	Algorithm development	
Preference for downloading process	Self-downloading	
Foreseen activities and support needs	Develop a land cover classification	
Project name	RUS_Project1	
Earth Observation Data information:		
Type of Earth Observation Data:		
Sentinel-1	1	
	S1-Product 1	
S1 - Product type	GRD	
S1 - Sensor mode	-	
S1 - Polarisation		
S1 - Orbit direction		
Sentinel-2	x	
Sentinel-3 Other	X	
I don't know	X	
Region of Interest:	x	
Min Latitude	39,3303	
Max Latitude	40.5877	
Min Longitude	-4.6736	
Max Longitude	-2.7205	
Reference polygons		
Data acquisition date(s):		
None		
Additional data specifications		
	conditions of RUS Service.	

Further to the acceptance of your request by the RUS Helpdesk, you will receive a notification email with all the details about your Virtual Machine. To access it, go to *Your RUS Service* \rightarrow *Your Dashboard* and click on *Access my Virtual Machine*.

							You are here: Home >	Your RUS service > Your dash
Your dashboard								
Request a new L	Jser Servi	ce						Chat with Support Desk
Project Name	ID	Date of submission	Status		Actions		Virtual	Environment
	1.50	-		Follow my project	Get support	Close my service	Access my Virtual Machine(s)	Access my CPU monitoring dashboard
RUS_training1	231	2017-08-31	Open		Get a webinar kit	Rate my service	Freeze my Virtual Machine(s)	Report a technical incident

Fill in the login credentials that have been provided to you by the RUS Helpdesk via email to access your RUS Copernicus Virtual Machine.



This is the remote desktop of your Virtual Machine.

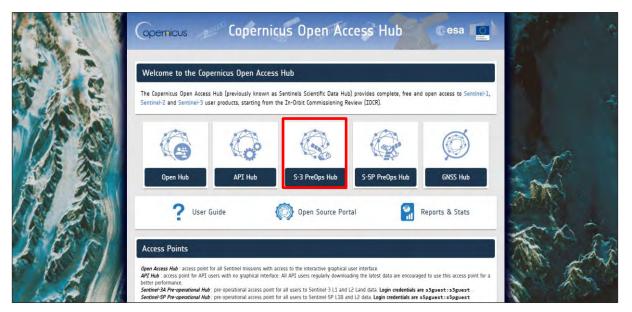
S Applications				
Alu System Redex	Schweiding.	00 389	R	SNAP
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duree Tradi				
CORUS				
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6 Step by step

6.1 Data download - ESA SciHUB

Before starting the exercise, make sure you are registered in the Copernicus Open Access Hub so that you can access the free data provided by the Sentinel satellites.

Go to https://scihub.copernicus.eu/



Go to *S-3 PreOps Hub*. If you do not have an account, sign up in the upper right corner, fill in the details and click register.



You will receive a confirmation email on the e-mail address you have specified: open the email and click on the link to finalize the registration.

Once your account is activated – or if you already have an account – log in.

6.2 Download data

In this exercise, we will analyse 2 Sentinel-3A images acquired during August 2018. Navigate to the London area, switch the pan mode to drawing by clicking on the icon in the upper right corner of the map (Green arrow) and draw a rectangle as indicated below. Open search menu by clicking at the left of the search bar (\equiv), specify the following parameters and press the search button (\square):

Sensing period: From 2018/08/02 to 2018/08/02 Check Mission: Sentinel-3 | Product type: SL_2_LST__

eesa op	emicus	_		Sentinel-3 Pre-Operations Data Hub	±°0 ↑
Insert search order Sort By: Order By: Order By: Sensing period Ingestion period Mission: Secture:-3 Satellite Platform Timeliness Product Level	Ingestion Da	er rseeac to to Product Type SL-2_LST	Citar 	Constrained Series Defense Beter	Lanue - Constant - Con
				to form form the set of the set o	nt Chinesi Chevaur am Kan Lizember Kantow Rent Sastructor Server Heldeler Ann Sistructor Server Heldeler Ann Sistructor Server Heldeler Strate Strategi Nan Sistructor Ministration Ungestation

In our case, the search returns 2 results (day and night acquisitions). Download both products by clicking on the arrow icon \clubsuit . Note the different sensing times of the images: S3A_SL_2_LST___20180802T100213 and S3A_SL_2_LST___20180802T200809



Once downloaded (@/home/rus/Downloads), move them to the following path and unzip them (right click -> Extract Here).

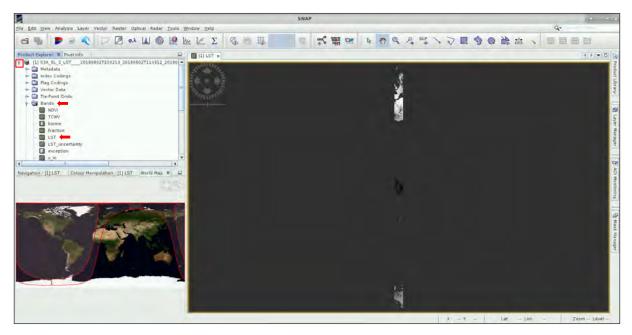
Path: /shared/Training/LAND09_UrbanHeatIsland_London/Original/

6.3 Sentinel-3 SNAP Processing

Open *SNAP Desktop* from your desktop (or *Applications -> Processing -> SNAP*), click on the *Open product* icon (*(*), navigate to the following path and open the day-time Sentinel-3 product from 2018-08-02 (S3A_SL_2_LST____20180802T**100213**). Open the folder and select the file *xfdumanifest.xml*. Then, click *OK*.

Path: /shared/Training/LAND09_UrbanHeatIsland_London/Original/

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.



6.3.1 Subset

The first step of the methodology will subset the image to reduce its original extent and number of bands. Select the Sentinel-3 SLSTR product in the *Product Explorer* and go to *Raster -> Subset*. In the *Spatial Subset* tab click on *Geo Coordinates* and introduce the following values:

North latitude bound: 54.211

West longitude bound: -6.362

South latitude bound: 49.095

East longitude bound: 3.312

In the *Tie-Point Grid Subset* tab, select only the bands *x_tx*, *y_tx*, *latitude_tx*, *longitude_tx*.

In the *Band Subset* tab, select only the bands *NDVI*, *biome*, *fraction*, *LST*, *x_in*, *y_in*, *latitude_in*, *longitude_in*. Then, click OK (click *No* in the pop-up flag dataset window).

Once created, the subset product will appear in the *Product Explorer*. Do not forget to save it (right click on it -> Save Product) in the following path (click *YES* in the pop-up window):

Path: /shared/Training/LAND09_UrbanHeatIsland_London/Processing/

	Specify Product Subset	+ = ×	Specify	Product Subset	+ = ;
Spatial Subset Band S	Subset Tie-Point Grid Subset Metada	ta Subset	Spatial Subset Band Subset	Tie-Point Grid Subset Metadata Su	bset
	Use Preview	ates 54.211 * -6.862* -49.095* - 3.312* - 1* - - - - - - - - - - - - -	<pre> Lt Just Just</pre>	Geolocated x (across track) coor Geolocated y (along track) coor Latitude of detector FOV centre Longitude of detector FOV centre Satellite azimuth angle Distance from satellite to surface Satellite zenith angle Distance from sun to surface Solar zenith angle Fractional cloud cover 2m dew point East-west integrated surface win East-west integrated surface win	inate of dete on the earth' on the eart e d stress
		v storage size: 82.0M Cancel Help		Estimated, raw stor	

NDVI	Gridded Normalized Difference Vegetation Index				
TCWV	Gridded Total Column Water Vapour				
V biome	Gridded GlobCover surface classification code				
🖌 fraction	Gridded fractional vegetation cover				
LST	Gridded Land Surface Temperature				
LST_uncertainty	Gridded Land Surface Temperature estimated total uncertainty				
exception	Gridded LST pixel exception flags				
₩ ×_in	Geolocated x (across track) coordinate of detector FOV centre				
⊮ y_in	Geolocated y (along track) coordinate of detector FOV centre				
bayes_in					
cloud_in					
🔲 confidence_in					
pointing_in					
probability_cloud_dual_in	Probability of cloud in pixel (dual view)				
probability_cloud_single_in	Probability of cloud in pixel (single view)				
elevation_in	Surface elevation of detector FOV centre above reference ellipso				
🖌 latitude_in	Latitude of detector FOV centre on the earth's surface				
🖌 longitude_in	Longitude of detector FOV centre on the earth's surface				
detector_in	Gridded pixel detector number				
🔲 pixel_in	Gridded pixel number				
🔲 scan_in	Pixel scan number				
🗌 Select <u>a</u> ll 📋 Select <u>n</u>	one				

6.3.2 Reproject

Once the product has been saved, we will reproject the Sentinel-3 SLSTR product to an appropriate map projection. Go to *Raster -> Geometric operations -> Reprojection*. In the *I/O Parameters* tab, make sure you select the subset product (index [2]) as input, change the output name to *LST_20180802_day* and make sure you set the output directory to the following path:

Path: /shared/Training/LAND09_UrbanHeatIsland_London/Processing/

In the *Reprojection Parameters* tab, click on the *Projection* drop-down menu and select UTM / WGS 84 (Automatic). Then, click Run.

Reprojection	+ E ×		Reprojection	* = *
File Help		File Help		
I/O Parameters Reprojection Parameters		1/O Parameters R	Reprojection Parameters	
Source Product Name: [2] subset_0_of_S3A_SL_2_LST20180802T10	0213_20 💌	Coordinate Reference	ce System (CRS)	
Target Product				
Name: LST_20180802_day		Projection:	UTM / WGS 84 (Automatic) Projection	Parameters
Save as: BEAM-DIMAP		O Predefined CRS		Select
Directory: ared/Training/LAND09 UrbanHeatIsland Lond	on/Processing/	O Use CRS of		T 10
Øpen in SNAP		Output Settings	ition 🕑 Reproject tie	-point grids
		Output Paran	neters No-data value:	NaN
		Add delta lat/lon	bands Resampling met	hod: Nearest 💌
		Output Information Scene width: 237 p	oixel Center longitud	le: 0°03'13" E
		Scene height: 154 p CRS: UTM	oixel Center latitude: Zone 31 / World Geodetic Syste	
	<u>R</u> un <u>C</u> lose	1	[<u>R</u> un <u>C</u> lose

6.3.3 Subset

After reprojection, we will subset the product to its final extent. For that, select the reprojected product in the *Product Explorer* and go to *Raster -> Subset*. In the *Spatial Subset* tab click on *Geo Coordinates* and introduce the following values:

North latitude bound: 52.372

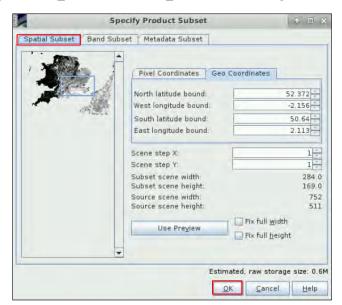
West longitude bound: -2.156

South latitude bound: 50.64

East longitude bound: 2.113

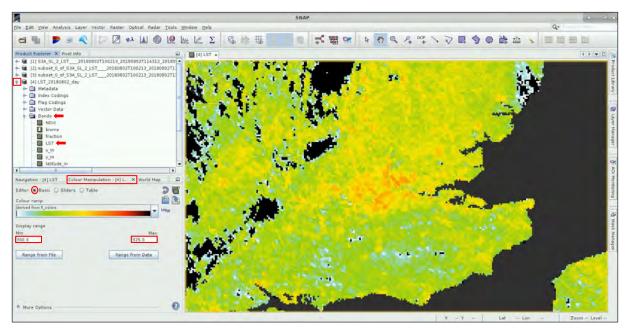
Once created, the subset product will appear in the *Product Explorer*. Do not forget to save it (right click on it -> Save Product) in the following path (click *YES* in the pop-up window) with the name *LST_20180802_day*

Path: /shared/Training/LAND09_UrbanHeatIsland_London/Processing/



In the *Product Explorer,* expand the reprojected product (index [4]) by clicking in the left arrow. Expand the *Bands* folder and double click on the band *LST* to visualize it.

Click on the *Colour Manipulation* tab (in the lower left corner), select *Basic* as *Editor* and click on the *5_colors* colour ramp. Set the *Min* and *Max* values to 300 and 325 respectively. Do not forget to save the product afterwards (right click on it -> *Save Product*).



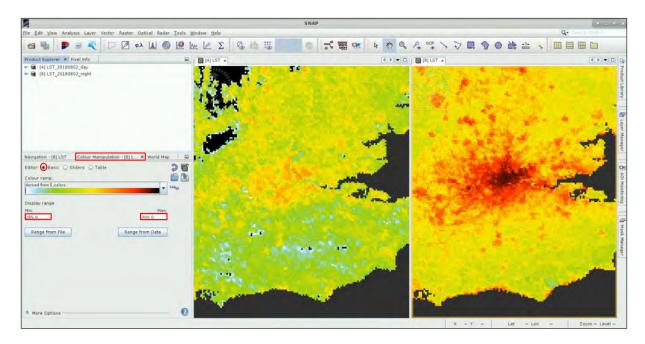
Once the product has been processed, we need to run the same steps (*Subset* + *Reprojection* + *Subset*) for the 2018-08-02 night product (S3A_SL_2_LST____20180802T**200809**). Click on the *Open product* icon (*(*), navigate to the following path and open the night-time Sentinel-3 product from 2018-08-02.

Repeat the steps as explained before and named the final product *LST_20180802_night*. For the night product, set the *Min* and *Max* values to 285 and 300 respectively and do not forget to save the product afterwards (right click on it -> *Save Product*).

Path: /shared/Training/LAND09_UrbanHeatIsland_London/Original/

Once both products are opened, go to *Windows -> Tile Horizontally* to combine both views and compared the temperatures (K). Click on the *Pixel info* tab and move the mouse over the images to analysis pixel values. To avoid confusion, close now (right click on the product -> *Close product*) all the products except the *LST_20180802_day* and *LST_20180802_night*.

Product Explorer	Pixel Info ×			
Position				
Image-X		12	27 pixel	
Image-Y		7	79 pixel	
Longitude		0*04'28"	Wdegree	
Latitude		51*31'38*	Ndegree	
Map-X	70293	35.405735570	95 m	
Map-Y	57125	504,97938025	58 m	
∓ Time				
- Bands				
LST		299, 3200	01 K	
Tie-Point Grids Flags				
Snap to selecter	l pin			

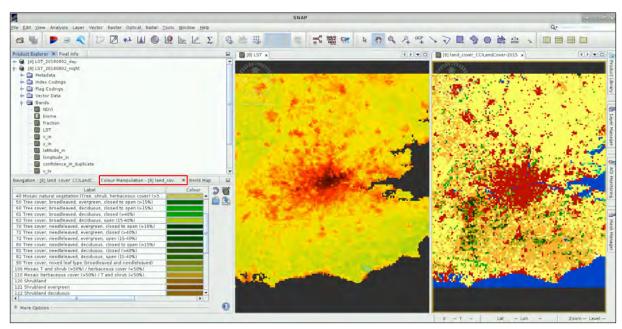


6.3.4 Add Land Cover Band

Once you have compared the different temperature (K) values between the day and night acquisition, close the *LST_20180802_day* product. To better identify the effect of an urban area in the temperature, we will subtract the average temperature of non-urban areas close to London. For that, we first add a land cover band to identify different land cover / land use. Right click on the *LST_20180802_night* product and select *Add Land Cover Band*. In the menu, go down, select *CCILandCover-2015* (See \square NOTE 1) and click OK. Do not forget to save to product afterwards.

NOTE 1: More information on the CCI Land Cover project can be found here - https://bit.ly/2MGSXdw

In the *Bands* folder of the *LST_20180802_night* product, double click on the land cover band (*land_cover_CCILandCover-2015*) to visualize it. Combine the visualization with the LST band by going to *Windows -> Tile Horizontally*. Use the *Pixel info* tab to identify the land cover code of each pixel.



You can find the legend for the different classes in the color manipulation tab of the land cover band.

6.3.5 Mean temperature

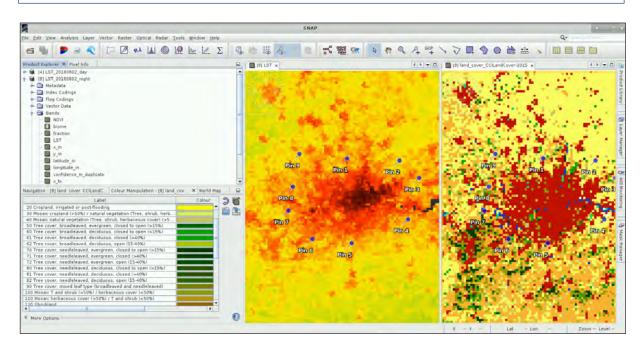
Once the land cover band is added, the next step is to derive the mean temperature in the surroundings of London using specific pixel values identified using the *Pin* tool of SNAP. Instead of creating those pins from scratch, we will load them directly. In the *Product Explorer*, select the *LST_20180802_night* product and go to *Vector -> Import -> ESRI Shapefile*. Navigate to the following path and select the file *pins_Point.shp*.

Path: /shared/Training/LAND09_UrbanHeatIsland_London/AuxData/

Once loaded, the *pins* are saved in the *Vector* folder of the *LST_20180802_night* product and can be visualized in the LST and Land Cover band (See \square NOTE 2) (See \square NOTE 3). Do not forget to save the product afterwards (right click -> *Save Product*).

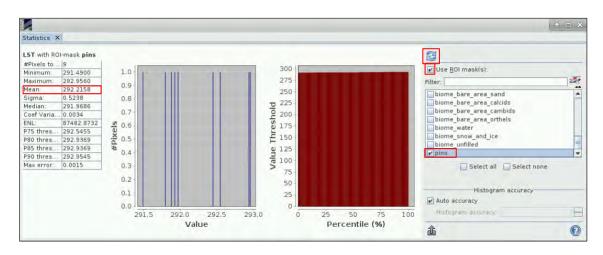
NOTE 2: If the *pins* are not loaded in the land cover band, close the visualization and open it again to refresh the view.

NOTE 3: To create your own Pins use the *Pin placing tool* (upper toolbar) of SNAP. Click on the Pin tool and add 9 pins around the city where the land use is different from urban areas. Use the land cover band, the *Pixel Info* tab and the *Color Manipulation* tab to help you in the process. Do not forget to save the product afterwards (right click -> Save product).



Once the pins are loaded in the image, we can derive the mean value for the pixels identified by the pins using the *Statistics* tool of SNAP. Close the land cover visualization and go to the menu *Analysis* - *Statistics*. Select the option *Select ROI Mask(s)*, go down in the list and select *pins*. Finally, press the refresh button.

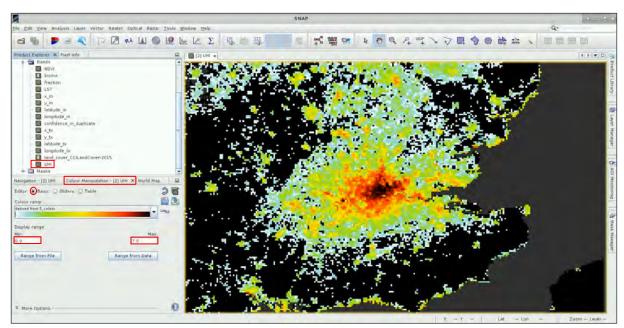
From the right-side panel, we can extract the mean temperature value (292.2158) using as reference the pins we have just inserted in our image.



We can now use the *Band Math* operator to subtract this value from the LST measurements. Right click on the *LST_20180802_night* product and select *Band Math*. Change the name to *UHI*, un-select *Virtual* and click on the *Edit Expression button*. Copy-paste the following expression and click *OK*:

Band Maths 💿 🐱	
Target product:	
[8] LST_20180802_night	
Name: UHI	
Description:	
Unit	
Spectral wavelength: 0.0	
Virtual (save expression only, don't store data)	
Replace Hall and infinity results by NaN	
Generate accudiated uncertainty band	
Band maths expression:	
LST - 292.2	
Load	

Close all previous visualizations except for the newly created *UHI* band. Click on the *Colour Manipulation* tab, select *Basic* as *Editor* and click on the *5_colors* colour ramp. Set the *Min* and *Max* values to 0 and 7 respectively. Do not forget to save the product afterwards (See \square NOTE 4).



NOTE 4: To remove the *Pins* from the visualization, open the *Layer Manager (Layer -> Layer Manager)* and unselect the option *Vector data.*

6.3.6 Export to QGIS

Once the result is ready, we will export it as GeoTIFF and open it in QGIS. For that, go to *File -> Export -> GeoTIFF*. Click on the *Subset* tab, and in the *Band Subset* menu select only the band *UHI*. Save the file with the name UHI_20180802 in the following path and click *Export Product:*

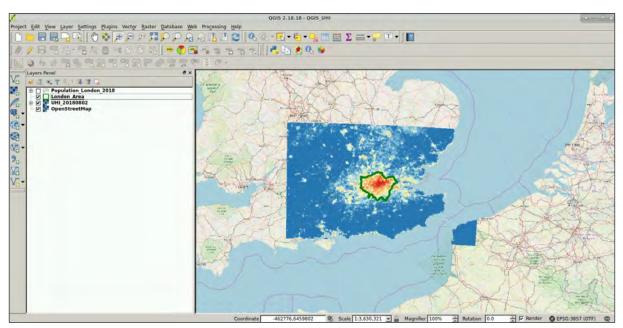
Path: /shared/Training/LAND09_UrbanHeatIsland_London/Processing/

	Spee	ify Product Subset 💡 v 🗉 🗙
	Spatial Subset Band Subset	Metadata Subset
		Gridded Normalized Difference Vegetation Index
	biome	Gridded GlobCover surface classification code
	fraction	Gridded fractional vegetation cover
	LST	Gridded Land Surface Temperature
	🔲 x_in	Geolocated x (across track) coordinate of detector FOV centre
SNAP - Export Product 💿 🗇 🖄	y_in	Geolocated y (along track) coordinate of detector FOV centre
	latitude_in	Latitude of detector FOV centre on the earth's surface
Save In: Processing	🔲 longitude_in	Longitude of detector FOV centre on the earth's surface
	confidence_in_duplicate	confidence_in.duplicate
LST_20180802_day.data Subset	x_tx	Geolocated x (across track) coordinate of detector FOV centre
subset 0 of S3A SL 2 LST 20180802T100213 20180802T114312 2018	y_tx.	Geolocated y (along track) coordinate of detector FOV centre
subset_0_of_S3A_SL_2_LST20180802T100213_20180802T114312_2018	atitude_t*	Latitude of detector FOV centre on the earth's surface
subset_1_of_S3A_SL_2_LST20180802T200809_20180802T214908_2018	longitude_tx	Longitude of detector FOV centre on the earth's surface
<pre>subset_1_of_S3A_SL_2_LST201808027200809_201808027214908_2018</pre>	Iand_cover_CCILandCover-201	6 CC/LandCover-2015
File Name: UHI 20180802	Select all Select none	
Files of Type: GeoTIFF product (*.tif,*.tiff)	-	Estimated you starting size 0.00
		Estimated, raw storage size: 0.0M
Export Product Cancel		<u>QK</u> <u>Cancel</u> <u>H</u> elp

6.4 QGIS Processing

Once the images are processed in SNAP, we will visualize the results in QGIS. Minimize SNAP and open QGIS, (*Applications -> Processing -> QGIS Desktop*). Although it is possible to open each raster individually, for convenience we will open a pre-saved QGIS session containing all the files. Go to *Project -> Open*, navigate to the following path and open the file *QGIS_UHI.qgs* (See \square NOTE 5).

Path: /shared/Training/LAND09_UrbanHeatIsland_London/AuxData/



NOTE 5: A basemap from OpenStreetMap will be used in the QGIS visualization. In case the OpenLayers plugin is not installed (not visible in the menu *Web -> OpenLayers plugin*), click on Plugins -> Manage and Install Plugins. Select the *'All'* tab on the right-side panel and write "OpenLayers plugin" on the search box. Select the plugin on the list and click 'Install Plugin'. Restart QGIS to finalize the installation.

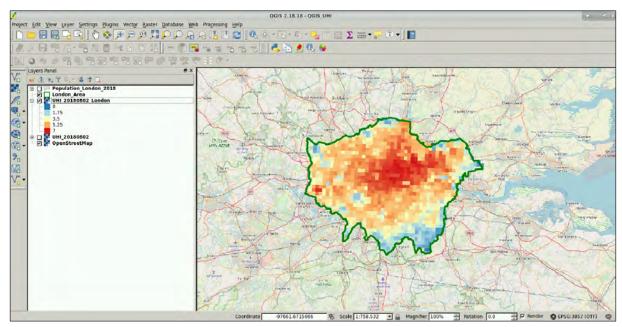
Once the products are opened in QGIS, we will clip the UHI_20180802 raster using as reference the shapefile of the extent of Greater London (*London_area.shp*). For this, go to *Raster -> Extraction -> Clipper*. Select UHI_20180802 as input file (raster) and set the output file to the following path:

Path: /shared/Training/LAND09_UrbanHeatIsland_London/Processing/UHI_20180802_London.tif

Select the option *No data value* and set it to -99. As *clipping mode* select *Mask layer* and select *London_Area* as mask. Select the option *Crop the extent of the target dataset to the extent of the cutline* and the option *Keep resolution of input raster*. Finally, click *Ok*.

Input file (raster)	UHI_2018080	02	-	Select
Output file	/Processing/U	HI_20180802_	London.tif	Select
✓ No data value	-99			3
Clipping mode		_		
C Extent		Mask la	iyer	
Mask layer Lor			<u> </u>	Select
Create an ou	tput alpha ban	d		
Crop the exte	ent of the targe	et dataset to th	e extent of t	he cutline
Keep resolut	ion of input ras	ter 🦵 Set ou	tput file reso	lution
Load into canva	s when finished	Ē.		
146.14294758 -o home/rus/shared/ essing/UHI_20180	Training/LANDO 0802.tif)9_UrbanHeatl)9_UrbanHeatl		-

Once the raster is clipped, we have to change its visualization to match the original one. Right click on the raster file UHI_20180802 and go to Styles -> Copy Style. Next, right click on the clipped raster (UHI_20180802_London) and go to Styles -> Paste Style.



In the last step, we will derive the mean temperature (and other statistics) per boroughs due to the Urban Heat Island effect. For this, we will use the *Zonal* Statistics tool to combine the information of the clipped raster with the shapefile of London's boroughs (*Population_London_2018.shp*).

Go to *Raster -> Zonal Statistics -> Zonal Statistics*. Select *UHI_20180802_London* as raster layer, select, *Population_London_2018* as *Polygon layer containing zones*, set _ as *Output column prefix* and select *Mean*, *Minimum and Maximum* as statistics to calculate.

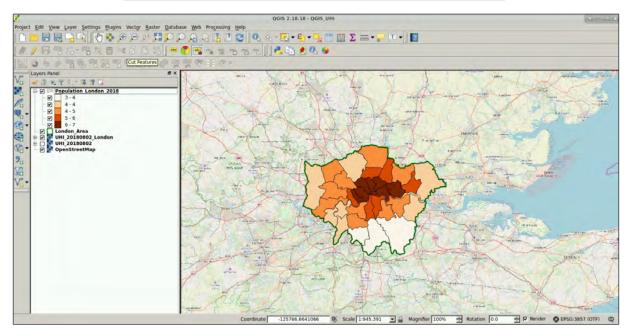
1	Zonal St	atistics	* = ×
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UHI_20180802_Lo	ndon		
Band		Band 1	
Polygon layer conta	aining the	zones:	
Population_Londor	1_2018		*
Output column pre	fix:		
-			
Statistics to calcula	ate:		
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Sum Mean			
Median Standard devia	tion		
Minimum	uon		
Range			
In Minority		_	-
		OK	Cancel
		<u></u>	

The statistics will be added to the attribute table of *Population_London_2018*. To visualize it, right click on the layer and select *Open Attribute Table*.

	NAME	Total_Pop	mean	min	max
1	Kingston upo	179581	3.782859010	1.418011426	5.034008979
2	Croydon	391296	3.153475628	1.206005811	5.547986030
з	Bromley	332733	2.645452342	-0.05400390	5.016003608
4	Hounslow	278264	4.654058297	1.762005567	5.896008491
5	Ealing	350784	4.801045390	2.435986280	6.068005561
6	Havering	257511	3.527528700	-0.18800659	5.953991889
7	Hillingdon	309926	3.841525408	0.810009777	6.763989448
8	Harrow	255369	4.625000313	2.888012647	5.408001899
9	Brent	336859	5.165189728	3.677990674	6.300000190
10	Barnet	397049	4.343623075	1.397991895	5.721997261

We can now visualize the mean temperature per neighborhood due to the Urban Heat Island effect. For this, activate the *Population_London_2018* layer on the *Layers Panel*, right click on it and go to *Properties.* In the right-side menu, go to *Style.* In the top part, select *Graduated* as display method, select *mean* as the column to be represented, set the precision parameter to 2 change the color ramp to *Oranges,* set the number of classes to 5 and click *Classify.* Finally, click *Ok* in the lower part.

<u>N</u>	Layer Properties - Population_London_2018 Style	a (i) (ii) (ii)
General	Graduated	1
🥑 Style	Column 1.2 mean	3 -
abo Labels	Symbol Chang	e
Fields	Legend Format %1 - %2	Precision 2 🛨 🏳 Trim
Rendering	Method Color	-
Display	Color ramp [source]	Edit Finvert
Actions	Classes Histogram	
joins 🚽		
🗾 Diagrams	3.5196 - 4.3937 4 - 4	
👔 Metadata	Y 2.6455 - 3.5196 3 - 4 Y 3.5196 - 4.3937 4 - 4 Y 4.3937 - 5.2678 4 - 5 Y 5.2678 6 - 1.419 5 - 6 Y 6.1419 - 7.0160 6 - 7	
	6.1419 - 7.0160 6 - 7	
Variables	Mode Equal Interval	Classes 5 🛨
Legend	Classify 🛞 🥽 Delete all	Advanced +
	☑ Link class boundaries	
	▼ Layer rendering	
	Layer transparency	0 =
	Layer blending mode Normal 💌	
	Feature blending mode Normal	
	Draw effects	
	Control feature rendering order	5.



To produce our final visualization, we first need to derive the population density. For this, we will use the *Raster calculator* tool available in QGIS to derive the area of each neighborhood (in km²) and divide the total population by this parameter. Right click on the *Population_London_2018* and select *Toggle Editing* to start the edition of this layer. In the toolbar, click on the *Open Field Calculator* icon - See NOTE 6).

NOTE 6: If not visible, go to *View -> Toolbars -> Attributes toolbar* to active the tools.

Make sure the option *Create a new field* is selected. Set the *Output field name* to Area_km2, change the *Output field type* to *Decimal number (real)* and set the *Precision* to 2. In the expression editor copy-paste the following expression and click *OK*.

\$area / 1000000

<u>X</u>	Field calculator	+ = ×
Only update 0 selected features Create a new field	— F Update	existing field
Create virtual field Output field name Area_km2 Output field type Decimal number (real Output field length 10 Precision Expression Function Editor		
= + - / • ^ () \m sarea / 1000000	From nu Aggrega Color Conversi Conversi Date an	Iunction Sarea Returns the area of the current feature. The area calculated by this function respects both the current projects ellipsoid setting and area unit settings. Eq. if an ellipsoid has been set for the project then the calculated area will be ellipsoid, and if no ellipsoid
N-1 N	 Fields an Fuzzy M General Geometry Math Operators Record String 	is set then the calculated area will be planimetric. Symax Sarea Examples • Sarea – 42
Output preview: 37.2786038417969	TimeMa	OK Cancel Help

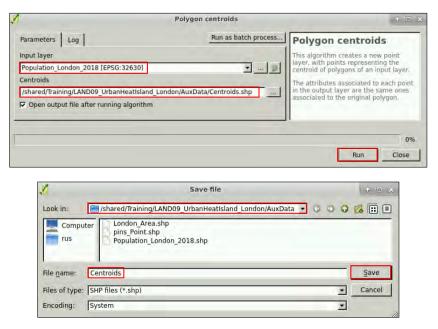
Next, open again the *Field Calculator*. Make sure the option *Create a new field* is selected. Set the *Output field name* to *Pp_den_km2* and leave the *Output field type* to *Whole number (integer)*. In the expression editor copy-paste the following expression and click *OK*.

1	Field calculator	1 D X
Only update 0 sele Create a new fiel Create virtual field	d ☐ ☐ ☐ Update existing fie	eld
Output field name Output field type Output field length Expression Funct	Vhole number (integer)	2
=+-/	II () in group Field From nu P Aggregates Double click to add expression string.	name to open context
Output preview: 481	Math Operators Record String TimeMan Variables Recent (fin. Load values)	all unique 10 samples

The new fields have been added to the attribute table of *Population_London_2018*. To visualize it, right click on the layer and select *Open Attribute Table*. Before continuing, right click on the *Population_London_2018* layer and click again in the *Toggle Editing* menu to stop the edition. Save the changes when asked.

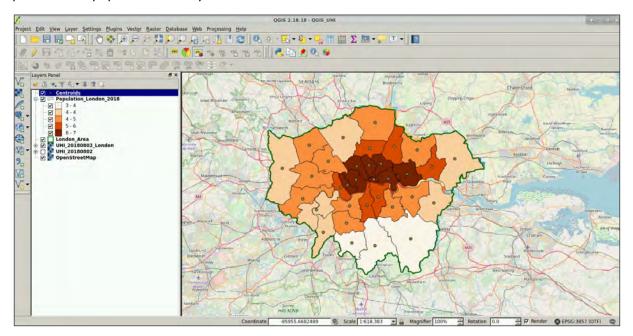
	NAME	Total Pop	maan			Area km2	Dn doo km2
			mean	min	max		Pp_den_km2
1	Barnet	397049	4.343623075	1.397991895	5.721997261	86.79	4575
2	Croydon	391296	3.153475628	1.206005811	5.547986030	86.54	4522
3	Enfield	337697	4.462366872	0.965985119	6.300000190	82.24	4106
4	Bexley	249999	4.194782122	1.409985303	5.758008003	60.61	4125
5	Richmond up	199419	3.855791851	1.409985303	5.056012153	57.38	3475

For the final visualization, we will combine the information of the mean temperature with the population density per neighborhood. For this, we will first derive the centroids of each polygon. Go to *Vector -> Geometry Tools -> Polygon Centroids*. Select *Population_London_2018* as input layer and save the output as *Centroids.shp* in the following path (click ... and select *Save to file*). Then, click *Run*.



Path: /shared/Training/LAND09_UrbanHeatIsland_London/AuxData/

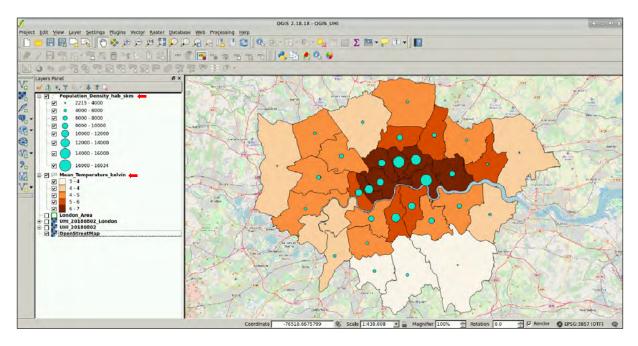
A new point shapefile has been added now to the *Layers Panel*. We will know link the size of the points to the population density of each area.



Right click on the *Centroids* layer and select *Properties*. In the right-side menu, go to *Style*. In the top part, select *Graduated* as display method, select *Pp_den_km2* as the column to be represented and click on the *Change* icon to set the color to light blue. Next, set the precision parameter to 0, change the *Method* to *Size* and make sure the size ranges from 1 to 8. Finally, select *Pretty intervals* as *Mode*, set the number of classes to 5, click *Classify* and *Ok*.

×.	Layer Properties - Population_Density_h	ab_skm Style 🔹 🐑 🔆
General	Graduated	1
o Style	Column 123 Pp_den_km2	3. 2
(abc) Labels	Symbol	• Change
Fields	Legend Format 81 - %2	Precision 0 🛨 🗂 Trim
Rendering	Method Size	×
🧊 Display	Size from 1.000000	Millimeter
	to 8.00000	*
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💽 Diagrams	✓ ● 4000.00 - 6000.00 4000 - 6000	
💮 Metadata	8000.00 - 10000.00 8000 - 10000	
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E Legend	 ✓ 14000.00 - 16000.00 14000 - 16000 ✓ 16000.00 - 16034.00 16000 - 16034 	
	Mode Pretty Breaks	Classes 5 ÷
	Classify 🛛 🛞 👝 🛛 Delete all	Advanced +
	✓ Link class boundaries	
	▼ Layer rendering	
	Layer transparency	이 🟥
	Layer blending mode Normal Feature blending mode Normal	1
	Draw effects	
	Control feature rendering order	<u>11</u>
	Style •	OK Cancel Apply Help

Finally, for visualization purposes, change the name of the *Centroids* and *Population_London_2018* to *Population_Density_hab_skm* and *Mean_Temperature_kelvin*



THANK YOU FOR FOLLOWING THE EXERCISE!

7 Further reading and resources

Sentinel-3 SLSTR User Guide

https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-slstr

Sentinel-3 SLSTR Technical Guide

https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-3-slstr

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