European Commission

JRC TECHNICAL REPORT

GHSL-S2 plugin User Guide

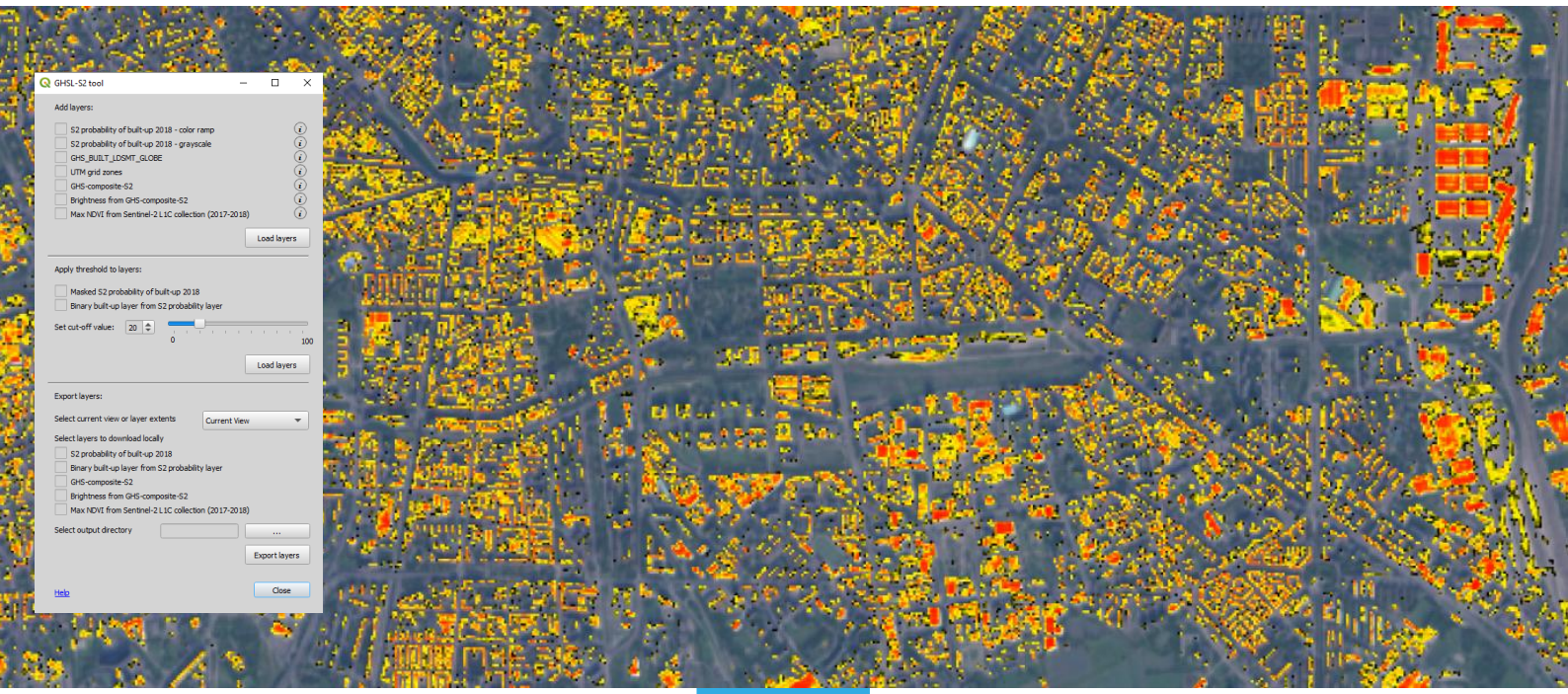
GHSL-S2 plugin
User Guide
Version 1.0

Politis, P.

Corbane, C.

Sabo, F.

2020



Joint Research Centre

Contact information
Name: Christina Corban
Address: Via Fermi, 2749 21027 ISPRA (VA) - Italy - TP 267
Email: christina.corban@ec.europa.eu
Tel.: +39 0332 78 3545

EU Science Hub
https://ec.europa.eu/jrc

JR121163

PDF ISBN 978-92-76-20747-4 doi:10.2760/094542

Luxembourg: Publications Office of the European Union, 2020

How to cite this report: Politis P., Corbane, C., Sabo, F., *GHS-S2 QGIS plugin User Guide*, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-79-20747- 4, doi:10.2760/094542, JRC121163.

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Authors

Politis, Panagiotis[b]; Corbane, Christina[a]; Sabo, Filip[b]

[a]European Commission – Joint Research Centre

[b]ARHS Developments S.A.

Abstract

The GHSL-S2 Tool (version 1.0) is a visualization and download tool (QGIS plugin) developed in the frame of the Global Human Settlement Layer (GHSL) project[1]. It facilitates the access to the GHSL S2 products using a free and open-source cross-platform Geographic Information System software (QGIS v.3.8 or higher). It provides a handy way to explore the GHSL datasets, to classify the probabilistic built-up layer derived from Sentinel-2 image composite and to export user-defined subsets, while avoiding the download of large files.

The GHS-S2 tool is developed in Python programming language as a QGIS plugin. It bridges the QGIS software[2] to the Google Earth Engine (GEE) cloud-based platform[3], making use of the GEE plugin[4], which integrates GEE and QGIS using the EE Python API[5]. It requires an active GEE account and an internet connection.

This document contains the description of the GHS-S2 tool usage, the main features and functionalities. The GHSL-S2 plugin is part of the GHSL tools suite and issued with an end-user licence agreement, included in the download package.

(1) https://ghsl.jrc.ec.europa.eu/
(2) https://qgis.org/
(3) https://earthengine.google.com/
(4) https://gee-community.github.io/qgis-earthengine-plugin/
(5) https://github.com/google/earthengine-api/tree/master/python

1 Introduction

Spatially consistent and up-to-date maps of human settlements are crucial for addressing policies related to urbanization and sustainability especially in the era of an increasingly urbanized world. The availability of open and free Sentinel-2 data of the Copernicus Earth Observation programme offers a new opportunity for wall-to-wall mapping of human settlements at a global scale.

Early 2020, a deep-learning-based framework has been developed by the GHSL team in collaboration with the Big Data project of I.3 unit for a fully automated extraction of built-up areas from a global composite of Sentinel-2 imagery [1], [2]. The method builds on Convolution Neural Networks architecture for pixel-wise image classification of built-up areas. The multi-neuro modelling methodology named GHS-S2Net allowed deriving the most detailed and complete map reporting about built-up areas for reference year 2018 [3].

The new built-up layer reports about the probability of 10 meter pixel to belong to built-up areas. The probability values are expressed in the range 0-100 with 255 as no-data value. The global dataset has been uploaded on Google Earth Engine and it can be easily accessed through the QGIS software using the GHSL S2 plugin, along with the above-mentioned cloud free image S2 global Composite for reference year 2018 and other associated geographic information layers produced in the framework of the GHSL.

Alternatively, the GHS-S2 built-up layer and the global Sentinel-2 composite can also be accessed and downloaded from the GHSL Datasets page[6] following a pre-defined tiling schema corresponding to UTM grid zones.

The utility of the tool lies in the possibility to explore the global Sentinel-2 composite in full resolution and the global GHS-S2 built-up layer, and to process these datasets with QGIS. It also includes other functionalities, such as the possibility to classify the probabilistic built-up layer and to export user-defined subsets, while avoiding the download of large files.

[6] https://ghsl.jrc.ec.europa.eu/datasets.php

2 Installation

2.1 System requirements and dependencies

The GHSL S2 QGIS plugin is a graphical tool developed in Python and Qt. It can be added as a QGIS plugin from the QGIS Plugins menu. The dependencies are ordered below:

- **QGIS version**: The GHSL S2 plugin is compatible with QGIS version 3.8 or higher. The most recent version can be downloaded here. The GHSL-S2 plugin is cross-platform (Windows, Linux, MacOS). Originally it has been built and compiled using a QGIS version 3.10.0 on Windows 10 64-bit version.
- **Internet connection**: A fast internet connection is essential (>5 Mbps) for fast rendering of the data.
- **QGIS Earth Engine plugin**: Install the QGIS Earth Engine plugin. The plugin can be installed from the

```
Plugins >> Manage and Install Plugins… >> search and select 'Google Earth Engine' >> Install Plugin
```

QGIS Plugin Repository as any other plugin:

- Authenticate using an **active Google Earth Engine account**: You need to have an active Google Earth Engine (EE) account to use the plugin. If you don't have one you can sign-up here.
To test if the plugin is installed and authenticated properly, type the following in the QGIS Python Console (Plugins → Python Console or press Ctrl+Alt+P).

```
>>> import ee
>>> print(ee.String('EE has successfully been installed!').getInfo())
EE has successfully been installed!
```

The first time you will be asked to authenticate to your account. This has to be done just once.

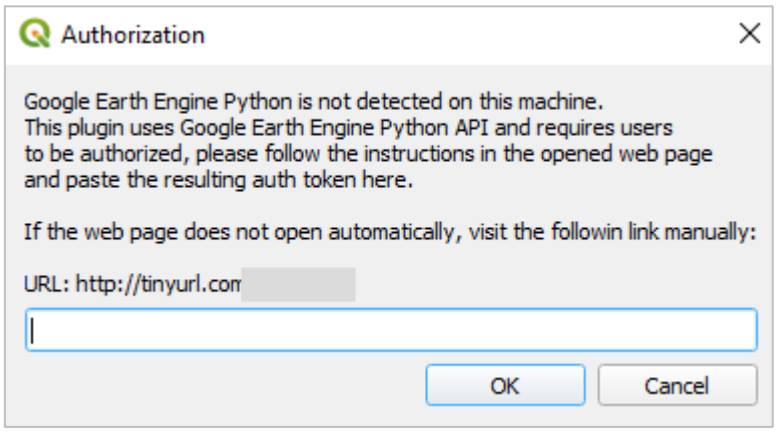

Figure 1. Authorization window

2.2 Installation procedure

The user can download the GHSL S2 plugin from the GHSL tool[7] page as zip file (GHSL_S2.zip, file size < 1MB).

Note: *The zip file is used for the installation. User doesn't have to unzip the file.*

The plugin can be installed locally (experimental plugin) from the menu:

```
Plugins >> Manage and Install Plugins… >> Install from ZIP >> point to the zip file
GHSL_S2.zip >> Install Plugin
```

It will take few seconds to install. The tool then can be loaded either from the 'Plugins' menu:

```
Plugins >> GHSL-S2 tool >> GHSL-S2 tool
```

or from the GHSL icon appeared in the Toolbar (Plugins) area.

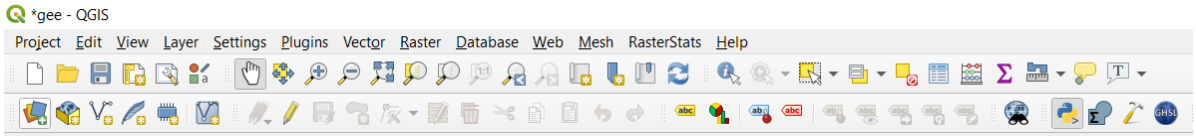

Figure 2. The GHSL S2 plugin initialization icon in the Plugins area on the bottom left corner.

[7] https://ghsl.jrc.ec.europa.eu/tools.php

3 Functionality

The graphical user interface is divided in three sections: 1. ''Add layers'', 2. ''Apply threshold value to layers'' and 3. ''Export Layers'' section.

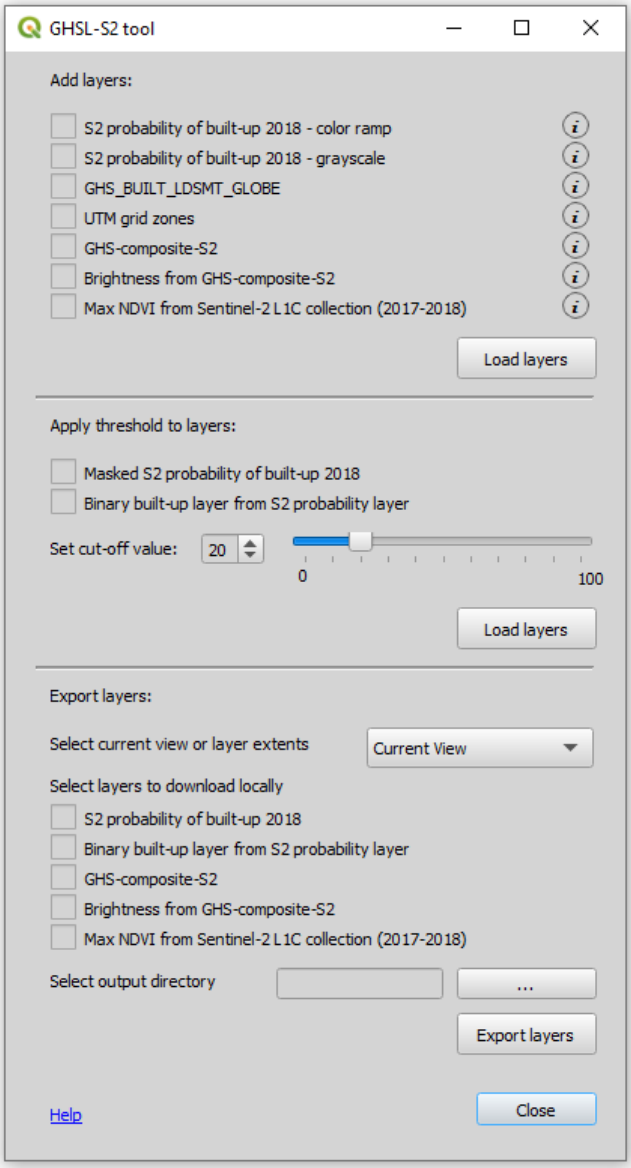

Figure 3. The graphical user interface of the GHSL-S2 QGIS plugin

3.1 Add layers

In this section user can select the layers to be added to the QGIS layer panel from a list of available layers described below. After selecting the layers from the check boxes the layers will be added on the QGIS layers panel by clicking on the 'Load layers' button.

Note: *Once the layers have been loaded, user can save the QGIS project (as .qgz project) and exit the QGIS. When the project is reloaded the layers will be loaded back, keeping the same parameters where applied, without the need to initialize the GHSL S2 plugin.*

Note: *On the right side of each layer there is a corresponding Identify tool.*

It allows you to interact with the map canvas and get information (pixel value) on each layer in a pop-up window, once it is loaded. To exit from the identify tool, click on pan map or zoom in / out icons on the Map Navigation toolbar.

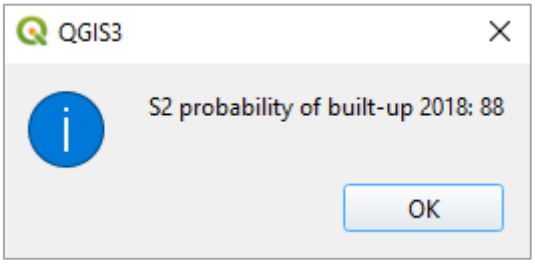

Figure 4. Pop-up window of the identify tool, showing a pixel value of the 'S2 probability of built-up 2018' layer

3.1.1 S2 probability of built-up 2018 - colour ramp

It corresponds to the probability of a 10-meter pixel to belong to built-up areas obtained from a Convolution Neural Networks architecture for pixel-wise classification of a global Sentinel-2 image composite for reference year 2018. Values are in the range 0 – 100 corresponding to probability values in the range 0 – 1. The results are rendered following a colour ramp from yellow for low probability values to red for high probability values.

Spatial resolution: 10 meters

Data type: Byte

No data value: 255

Colour ramp: 0 100

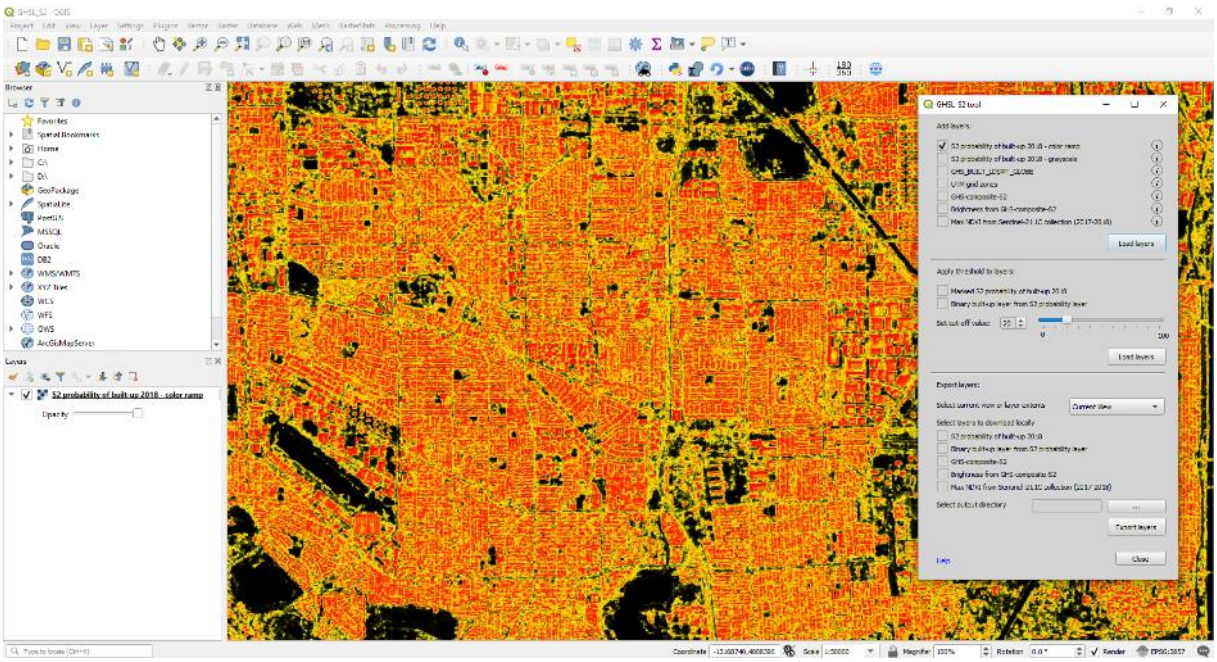

Figure 5. Visualization of the 'S2 probability of built-up 2018' layer over Los Angeles

3.1.2 S2 probability of built-up 2018 - grayscale

Probability of a 10-meter pixel to belong to built-up areas obtained from a Convolution Neural Networks architecture and applied to classification of a global Sentinel-2 image composite for reference year 2018. Values are in the range 0 - 100 corresponding to probability values in the range 0 – 1. The results are displayed using a grayscale rendering.

Spatial resolution: 10 meters

Data type: Byte

No data value: 255

Colour ramp: 0  100

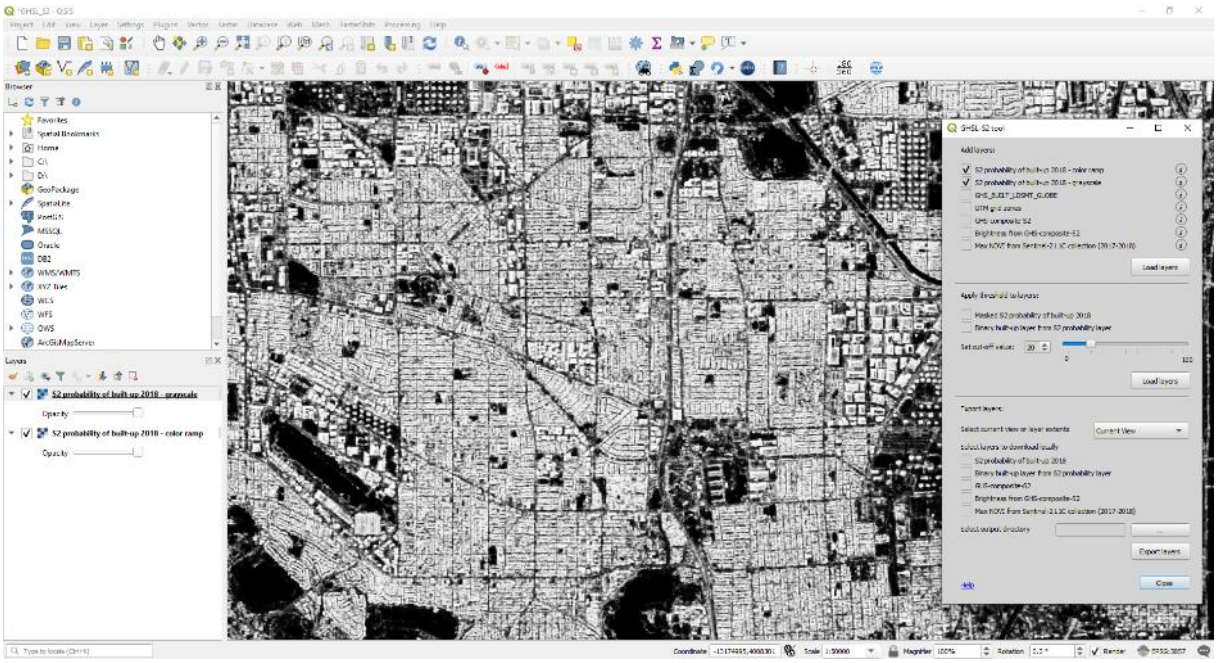

Figure 6. The 'S2 probability of built-up 2018 grayscale' layer over the same area in Los Angeles

3.1.3 GHSL MT2017 Landsat: GHS_BUILT_LDSMT_GLOBE

Multitemporal information layer on built-up presence as derived from Landsat image collections (GLS1975, GLS1990, GLS2000, and ad-hoc Landsat 8 collection 2013/2014) [4].

Transparent (0): no data

Blue colour (1): water surface

Black colour (2): land no built-up in any epoch

White colour (3): built-up from 2000 to 2014 epochs

Yellow colour (4): built-up from 1990 to 2000 epochs

Orange colour (5): built-up from 1975 to 1990 epochs

Red colour (6): built-up up to 1975 epoch

Spatial Resolution: 30 meters

Data type: Byte

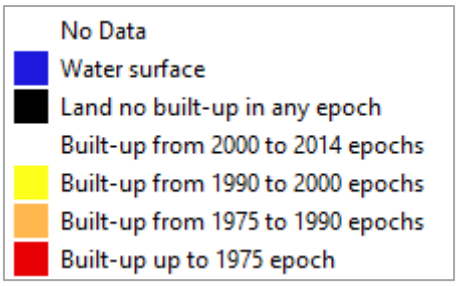

Figure 7. GHSL MT2017 Landsat colour map

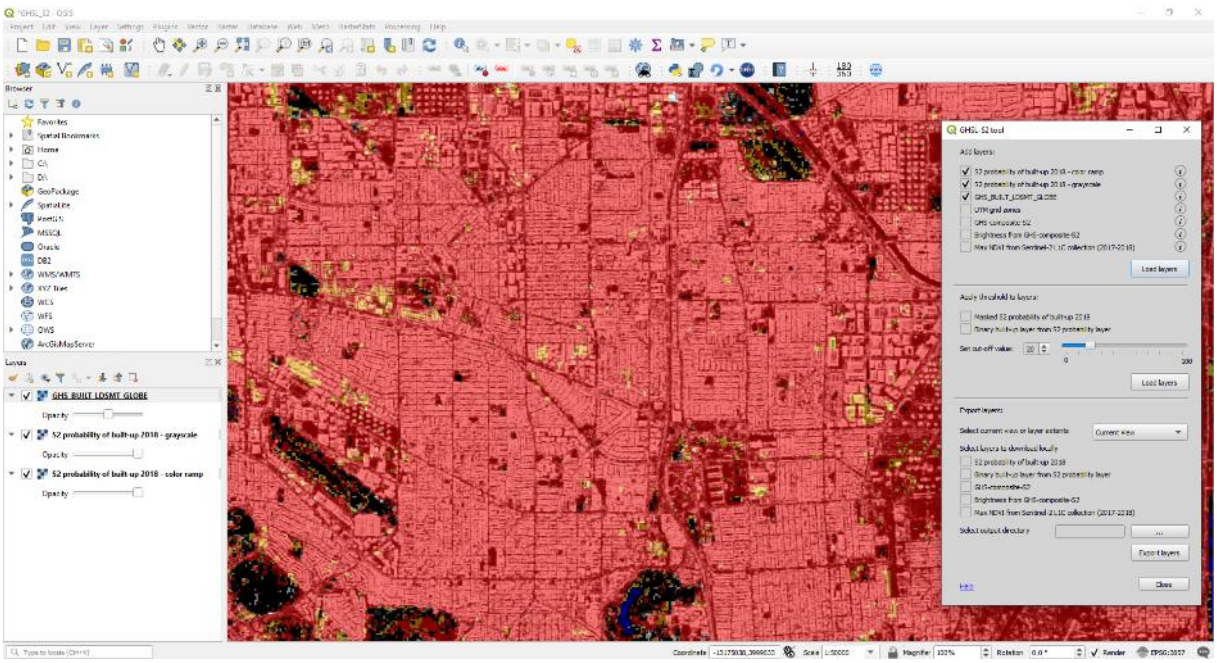

Figure 8. Visualization of the 'GHSL MT2017 Landsat' layer, semi-transparent over the S2 probability of built-up layer, Los Angeles area

3.1.4 UTM grid zones

The GHS-S2 built-up layer and the global Sentinel-2 composite have been produced and tiled following a pre-defined tiling schema, the Universal Transverse Mercator (UTM) system, with each tile having the projection of the UTM zones (UTM/WGS84 projection) to which it corresponds to. There are in total 615 grid zones with data covering mostly mainland and islands.

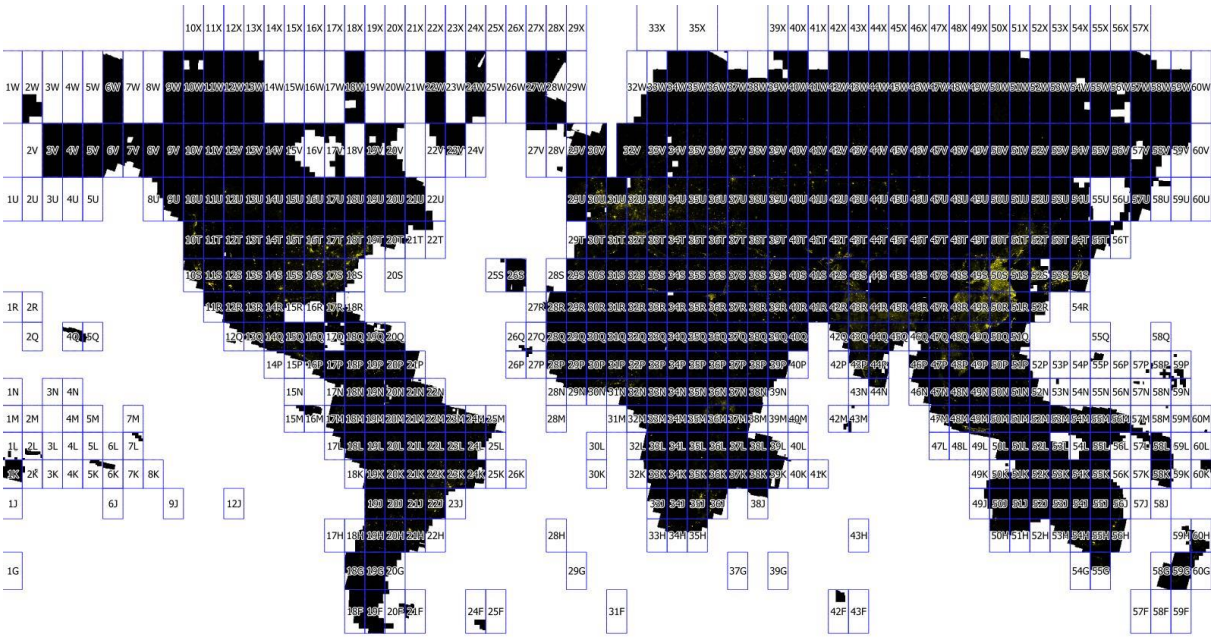

Figure 9. The UTM grid zones covering mainland and islands

3.1.5 S2 composite percentile: GHS-composite-S2

Global cloud-free pixel based composite created from the Sentinel-2 data archive (Level L1C) available in Google Earth Engine for the period January 2017-December 2018.

Composed of four spectral bands (B2: Blue, B3: Green, B4: Red and B8: Near Infrared). Displayed in a combination of red, green and blue band (B4, B3, B2).

Spatial resolution: 10 meters

Data type: UInt16

Compositing method: 25th percentile

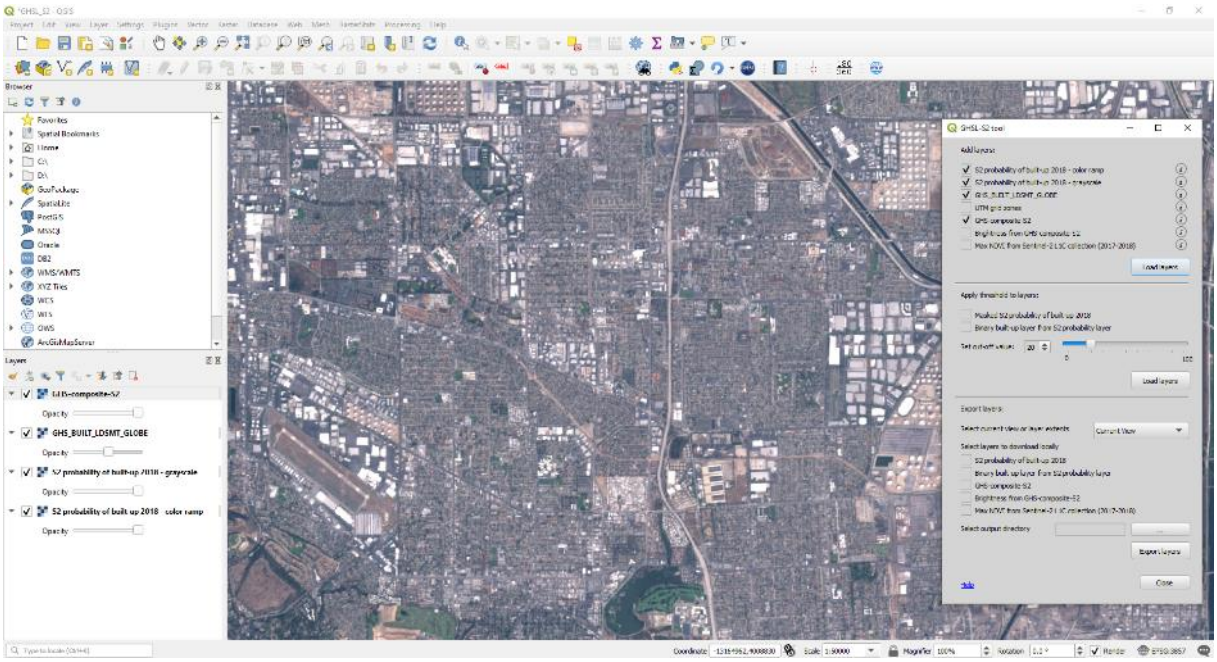

Figure 10. Natural colour (RGB) representation of the 4-bands 'GHS-composite-S2 layer' over Los Angeles

3.1.6 Brightness from GHS-composite-S2

Maximum value of the visible bands (B2: Blue, B3: Green, B4: Red) derived from the GHS-composite-S2, resulting a grayscale one band layer.

Spatial Resolution: 10 meters

Data type: UInt16

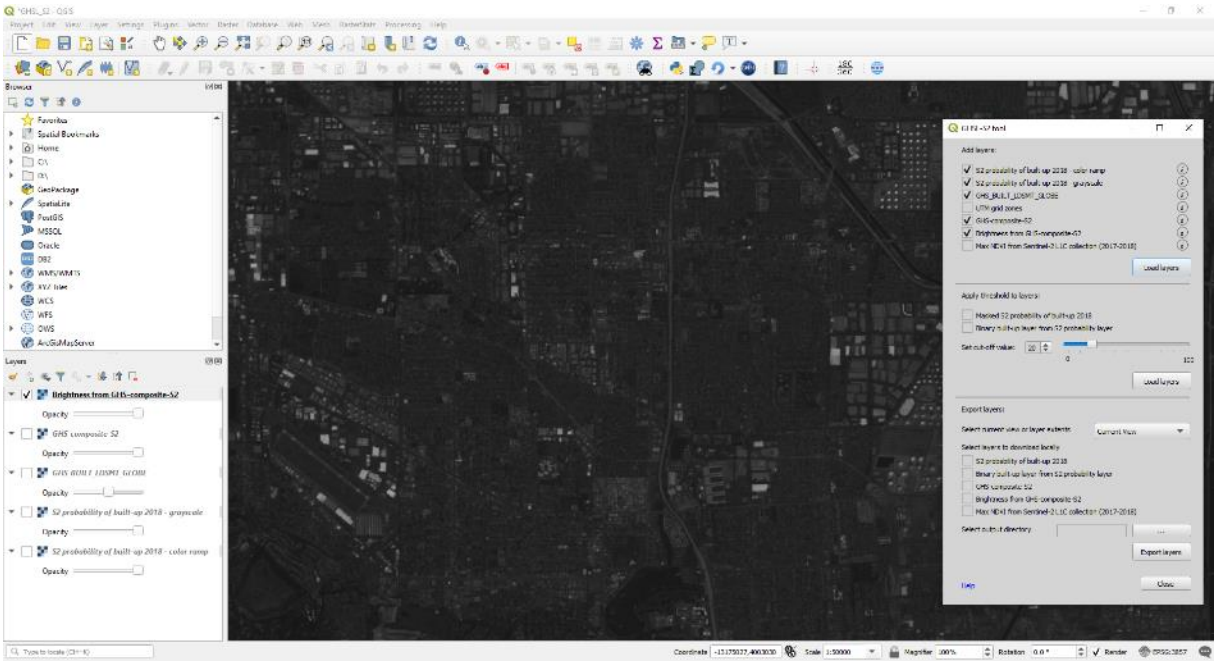

Figure 11. Grayscale representation of the 'brightness from GHS-composite-S2' layer over Los Angeles

3.1.7 Max NDVI from Sentinel-2 L1C collection in the period 2017-2018

Maximum value per pixel of the Normalized Difference Vegetation Index (NDVI) derived from Sentinel-2 L1C collection in the period 2017-2018. Values are in the range 0 – 1. The results are rendered following a colour ramp from red for low NDVI values to green for high NDVI values.

Spatial Resolution: 10 meters

Data type: Float32

Colour ramp: 0  1

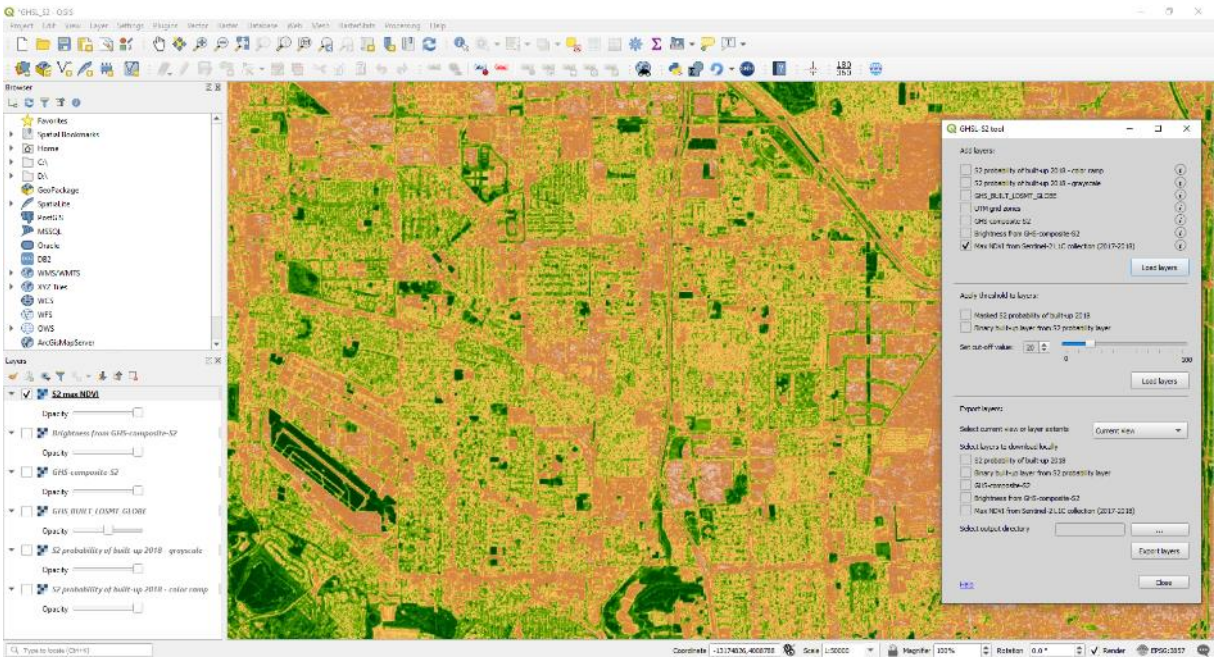

Figure 12. Max NDVI as derived from Sentinel-2 L1C collection in the period 2017-2018 over Los Angeles

Table 1. Characteristics of the available datasets

Layer	Spatial Resolution	Datatype	Data Range	Data Values	NoData Value	Band(s)
S2 probability of built-up 2018 - colour ramp	10m	Byte	Continuous	0-100	255	1 Band
S2 probability of built-up 2018 – grayscale	10m	Byte	Continuous	0-100	255	1 Band
GHSL MT2017 Landsat: GHS_BUILT_LDSMT_GLOBE	30m	Byte	Categorical	0,1,2,3,4, 5,6	0	1 Band
S2 composite percentile: GHS-composite-S2	10m	UInt16	Continuous	0-65535	0,0,0,0	4 Bands
Brightness from GHS-composite-S2	10m	UInt16	Continuous	0-65535	0	1 Band
Max NDVI from Sentinel-2 L1C collection in the period 2017-2018	10m	Float32	Continuous	0-1	N/A	1 Band

3.2 Apply threshold value to probability layers

With this option the user can specify a cut-off value to the probability layers and obtain a binary representation of built-up areas. The range is 0-100. The default cut-off value is 20. The horizontal slider and the spin box are interconnected and apply on-the-fly the user-selected cut-off value to the probability layer. The output of this operation is two new layers: the 'Masked S2 probability of built-up 2018' and the 'Binary built-up layer from S2 probability' layers respectively. Press ''Load Layers'' button to add the layers to your project.

Note: *In case of slow internet connection the slider might become irresponsive while moving as it is constantly calling the GEE. This can be overcome by typing the desired value and press the* ***TAB*** *button to enter the value.*

Table 2. Thresholded layers characteristics

Layer	Spatial Resolution	Datatype	Data Range	Data Values	NoData Value	Band(s)
Masked S2 probability of built-up 2018	10m	Byte	Continuous	0-100	255	1 Band
Binary built-up layer from S2 probability layer	10m	Byte	Categorical	0,1	N/A	1 Band

The layers in this section are briefly described below.

3.2.1 Masked S2 probability of built-up 2018

Masked S2 probability of built-up 2018. Select threshold value to apply to the S2 probability of built-up 2018. All values below the selected threshold are set to transparent.

Spatial Resolution: 10 meters

Data type: Byte

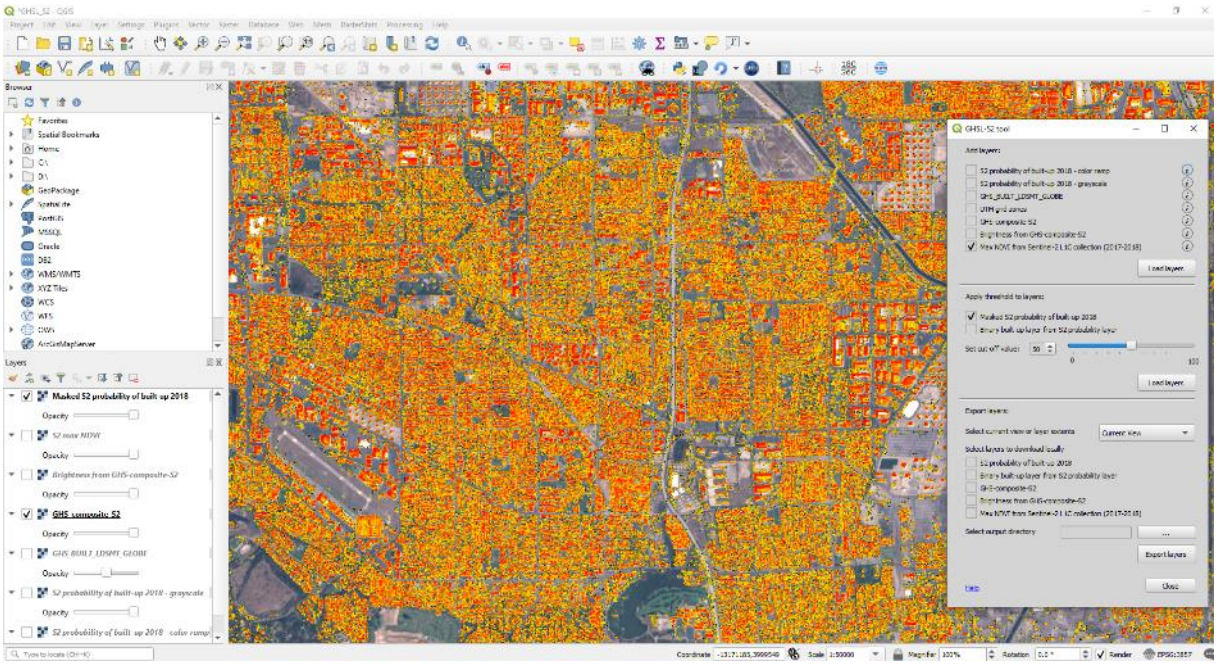

Figure 13. Visualization of the 'Masked S2 probability' layer over Los Angeles using as background the GHS-composite-S2. Selected cut-off value is 50.

3.2.2 Binary built-up layer from S2 probability layer

Select threshold value to apply to the S2 probability of built-up 2018. All values below the selected threshold are set to 0 and the values above set to 1.

Spatial Resolution: 10 meters

Data type: Byte

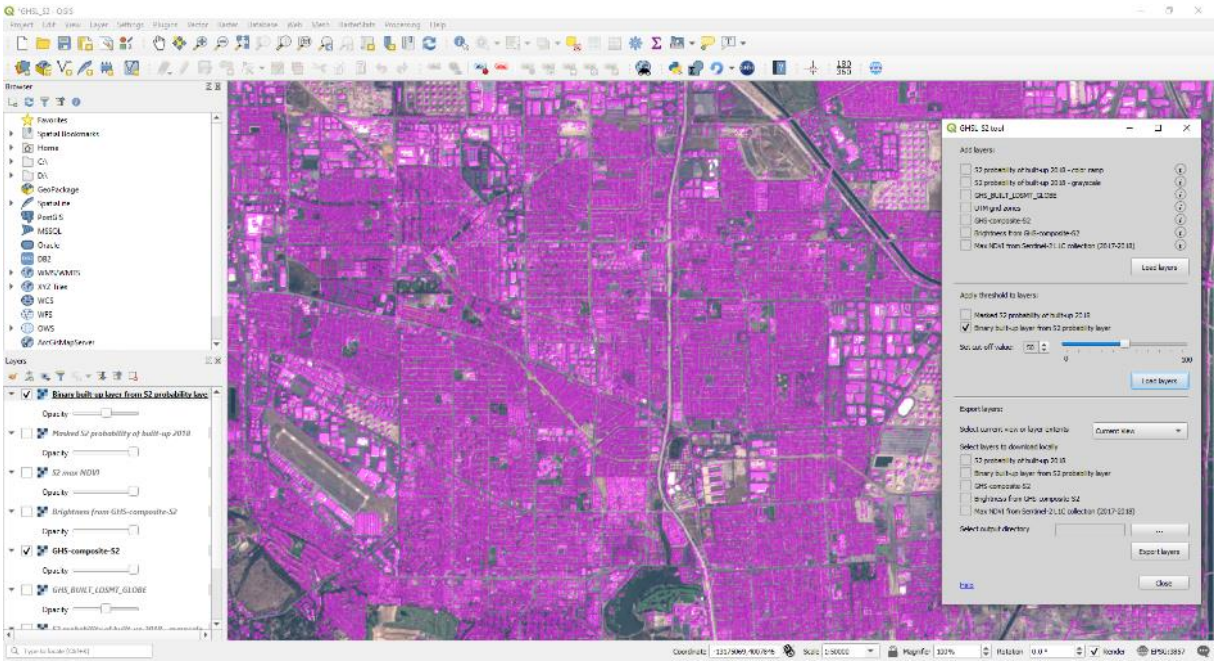

Figure 14. Visualization of the 'Binary built-up layer from S2 probability' layer half-transparent over Los Angeles using as background the GHS-composite-S2. Selected cut-off value is 50.

3.3 Export Layers

3.3.1 Select current view or layer extent

Select the area to download the layers. You can choose either the current view window or the extents from any vector or raster layer loaded in the QGIS Layers Panel.

Note: *The layers will be downloaded using the* ***extents*** *and the* ***projection*** *of the selected layer used for clipping. In case of the "****Current View****" selection it will consider the project properties projection.*

3.3.2 Select layers to download locally

Select the layers you want to download in the selected extents. Make sure you have already loaded them from the previous sections.

Note: *Download is limited to ~1GB per file due to GEE quota. With the version 0.1.224 of the Earth Engine Python API, the pixel grid dimensions of the exported grid must be less than or equal to 10.000x10.000 pixels). Split the area in smaller pieces if the download fails (max 100km x 100km area).*

3.3.3 Select output directory

Select folder to download the selected layers. The result is a zip file for each selected layer.

- S2 probability of built-up 2018:
  Export file: S2_Probability_BU_2018.zip

Image file: TIFF file
Spatial resolution: 10 meters
Datatype: Byte, 1 band
Values range: 0-100 (continuous)

- Binary built-up layer from S2 probability layer:
  Export file: S2_Binary_BU_gt_xx.zip *where xx: the cut-off value*
  Image file: TIFF file
  Spatial resolution: 10 meters
  Datatype: Byte, 1 band
  Values range: 0 or 1 (binary)
- GHS-composite-S2:
  Export file: S2_Binary_BU_gt_xx.zip *where xx: the cut-off value*
  Image file: TIFF file
  Spatial resolution: 10 meters
  Datatype: UInt16, 4 bands ('blue', 'green', 'red', 'nir')
  Values range: 0-65535 (continuous)
- Brightness from GHS-composite-S2:
  Export file: GHS_composite_S2_Brightness.zip
  Image file: TIFF file
  Spatial resolution: 10 meters
  Datatype: UInt16, 1 band
  Values range: 0-65535 (continuous)
- Max NDVI from GHS-composite-S2:
  Export file: GHS_composite_S2_NDVI_max.zip
  Image file: TIFF file
  Spatial resolution: 10 meters
  Datatype: Float32, 1 band
  Values range: 0-1 (continuous)

Table 3. Output layers characteristics

Layer	**Spatial Resolution**	**Datatype**	**Data Range**	**Data Values**	**NoData Value**	**Band(s)**
S2 probability of built-up 2018	10m	Byte	Continuous	0-100	255	1 Band
Binary built-up layer from S2 probability layer	10m	Byte	Categorical	0,1	N/A	1 Band
GHS-composite-S2	10m	Byte	Continuous	0-65535	0,0,0,0	4 Bands
Brightness from GHS-composite-S2	10m	UInt16	Continuous	0-65535	0	1 Band
Max NDVI from Sentinel-2 L1C collection in the period 2017-2018	10m	Float32	Continuous	0-1	-1	1 Band

Note: *Download is running as background process. A 'task complete' notification pop-up appears when the download is finished.*

References

[1] Corbane, C.; Politis, P. (2020): GHS-composite-S2 R2020A - Sentinel-2 global pixel based image composite from L1C data for the period 2017-2018. European Commission, Joint Research Centre (JRC) [Dataset] doi:10.2905/0BD1DFAB-E311-4046-8911-C54A8750DF79 PID: http://data.europa.eu/89h/0bd1dfab-e311-4046-8911-c54a8750df79

[2] Corbane, C., Politis, P., Kempeneers, P., Simonetti, D., Soille, P., Burger, A., Pesaresi, M., Sabo, F., Syrris, V. and Kemper, T., 'A global cloud free pixel-based image composite from Sentinel-2 data', DATA IN BRIEF, ISSN 2352-3409 (online), 31, 2020, p. 105737, JRC120356, doi: https://doi.org/10.1016/j.dib.2020.105737

[3] Corbane, C., Syrris, V., Sabo, F., Politis, P., Melchiori, M., Pesaresi, M., Soille, P., Kemper, T., 'Convolutional Neural Networks for Global Human Settlements Mapping from Sentinel-2 Satellite Imagery', https://arxiv.org/abs/2006.03267

[4] Corbane, C.; Florczyk, A.; Pesaresi, M.; Politis, P.; Syrris, V. (2018): GHS built-up grid, derived from Landsat, multitemporal (1975-1990-2000-2014), R2018A. European Commission, Joint Research Centre (JRC), doi: 10.2905/jrc-ghsl-10007, PID: http://data.europa.eu/89h/jrc-ghsl-10007

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KJ-02-20-550-EN-N

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Publications Office of the European Union

doi:10.2760/094542

ISBN 978-92-76-20747-4