GIS Course

June 18-29 2018

Politecnico di Milano, Lecco Campus

POLITECNICO MILANO 1863

GEO4D

Geodesy and geoinformatics for sustainable development in Jordan

586070-EPP-1-2017-1-SE-EPPKA2-CBHE-JP

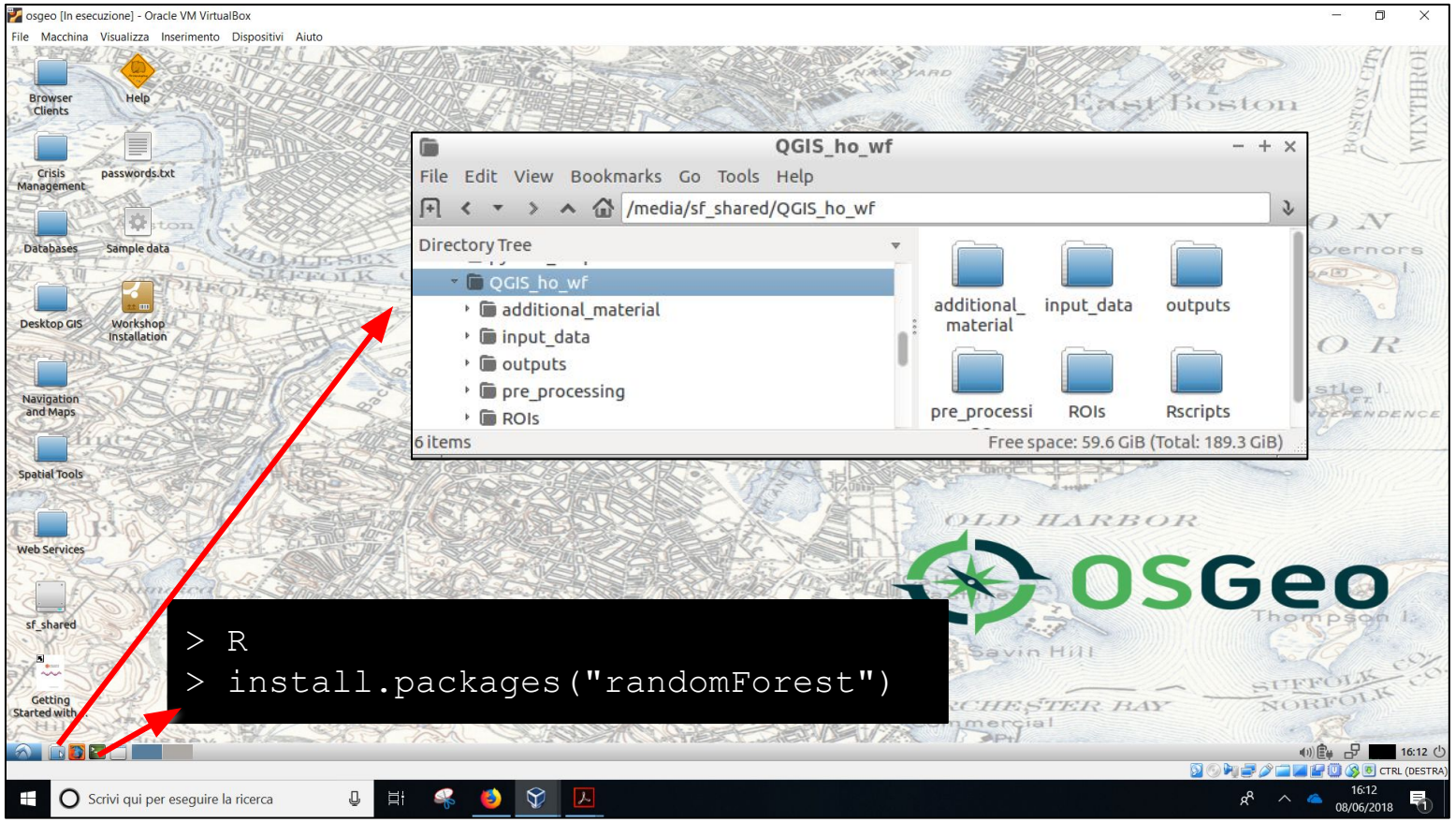
# Hands-on session: QGIS

Daniele Oxoli
Politecnico di Milano – DICA | GEOlab

18/06/2018

# Before starting...

✓ Be sure to have downloaded the folder “QGIS_ho_wf” and the **OSGeoLive** VM is properly installed on our laptop



# Lecture program and goals

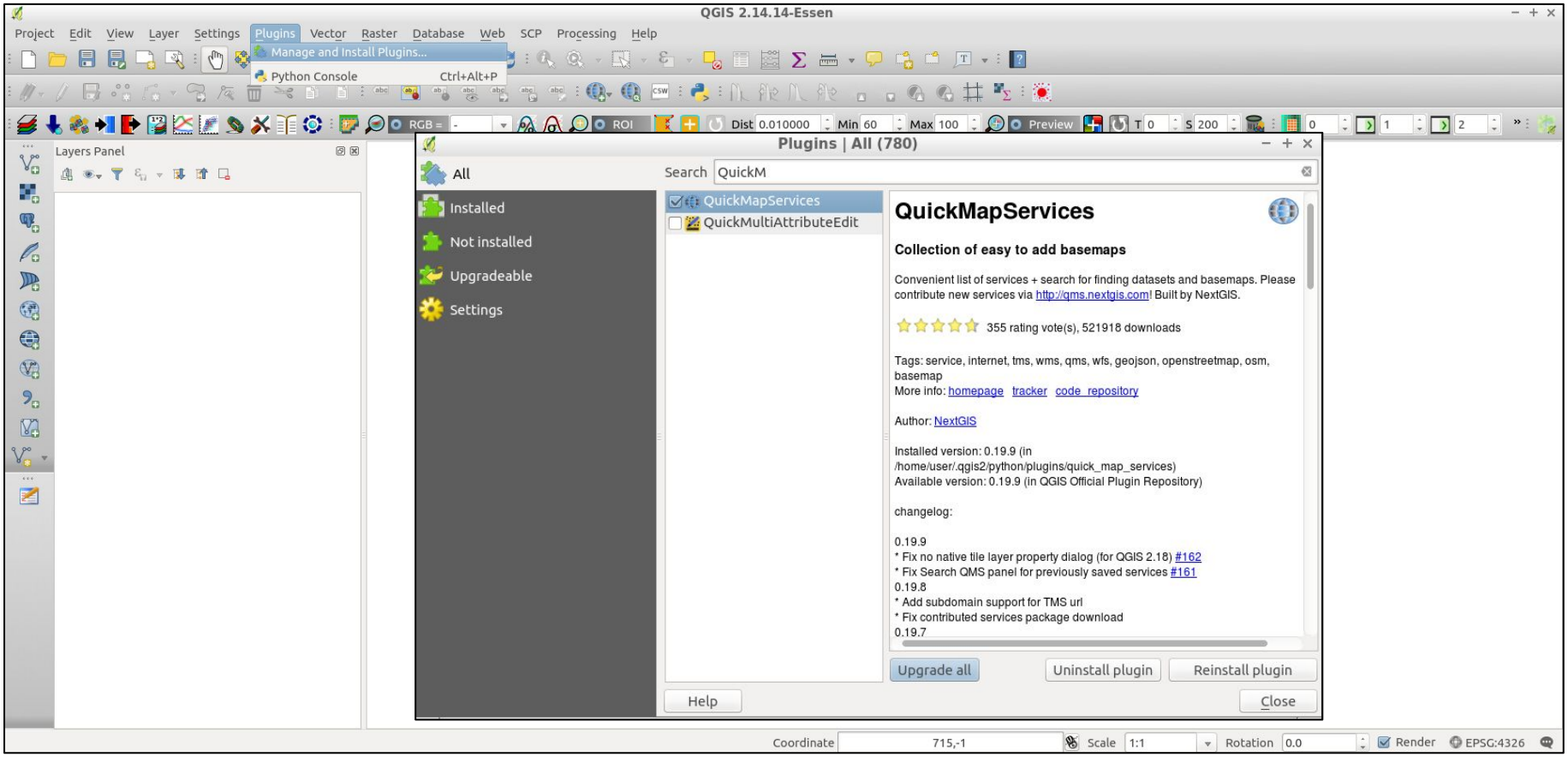
✓ Taste the power of **QGIS** for geodata managing and processing

✓ Topics

- **Retrieve satellite images with QGIS**
  - Basemaps
  - Open satellite imagery
- **Satellite images preprocessing**
  - Import bands + atmospheric correction
  - Band set
  - Virtual rasters
  - Clip
  - Styling a multispectral raster layer
- **Raster calculator**
- **Advanced vector layers editing**
- **Extending QGIS functionalities**
  - Add a custom script to the Processing Toolbox
  - Perform a supervised image classification for built-up areas

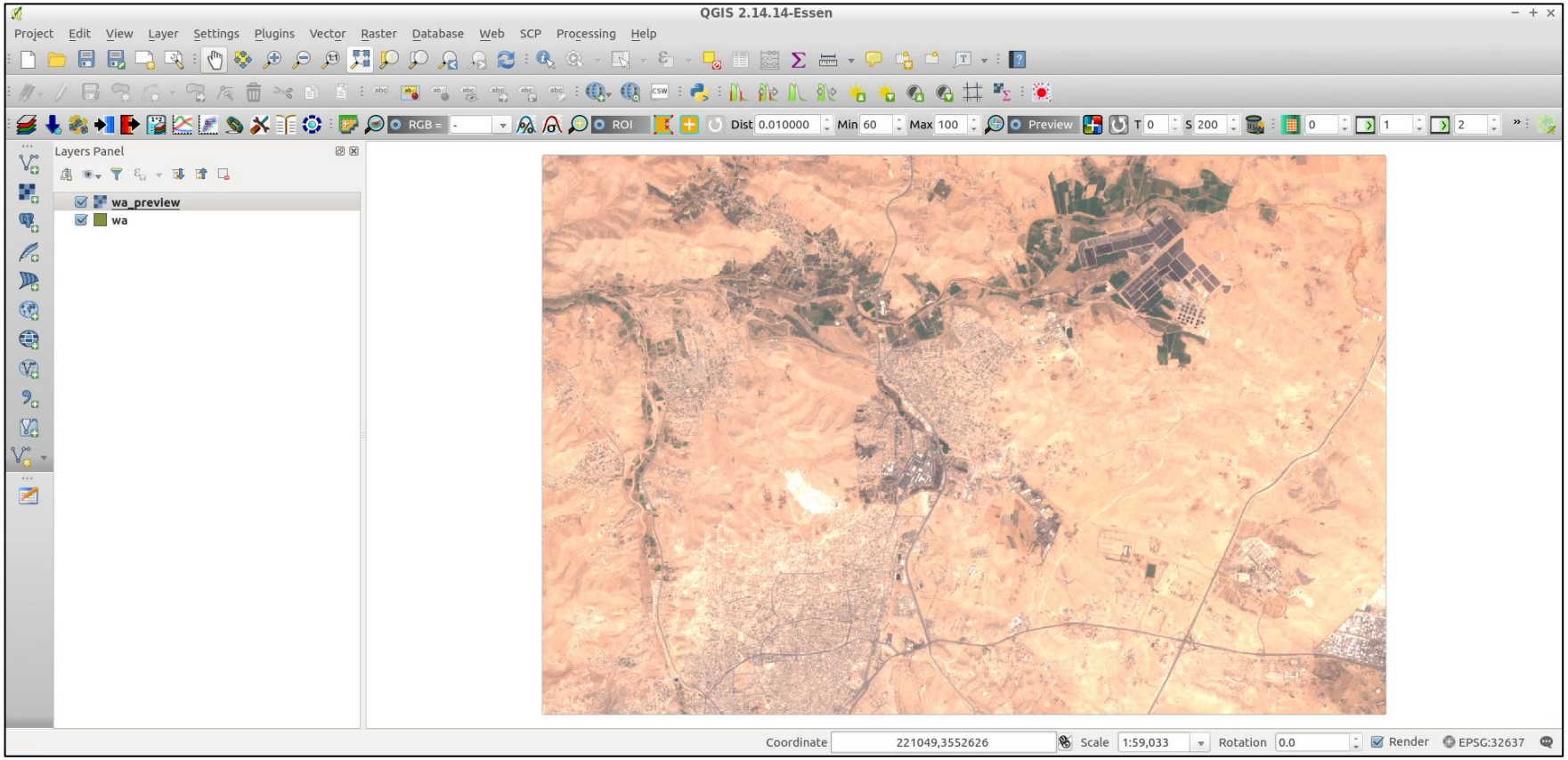
# Retrieve satellite images with QGIS: Basemaps

✓ Open QGIS. On the Bar Menu select ***Plugin*** → ***Menage and install Plugins*** to activate the ***QuickMapServices*** Plugin. This Plugin provides a collection of 'easy-to-add' basemaps to be used in your QGIS projects



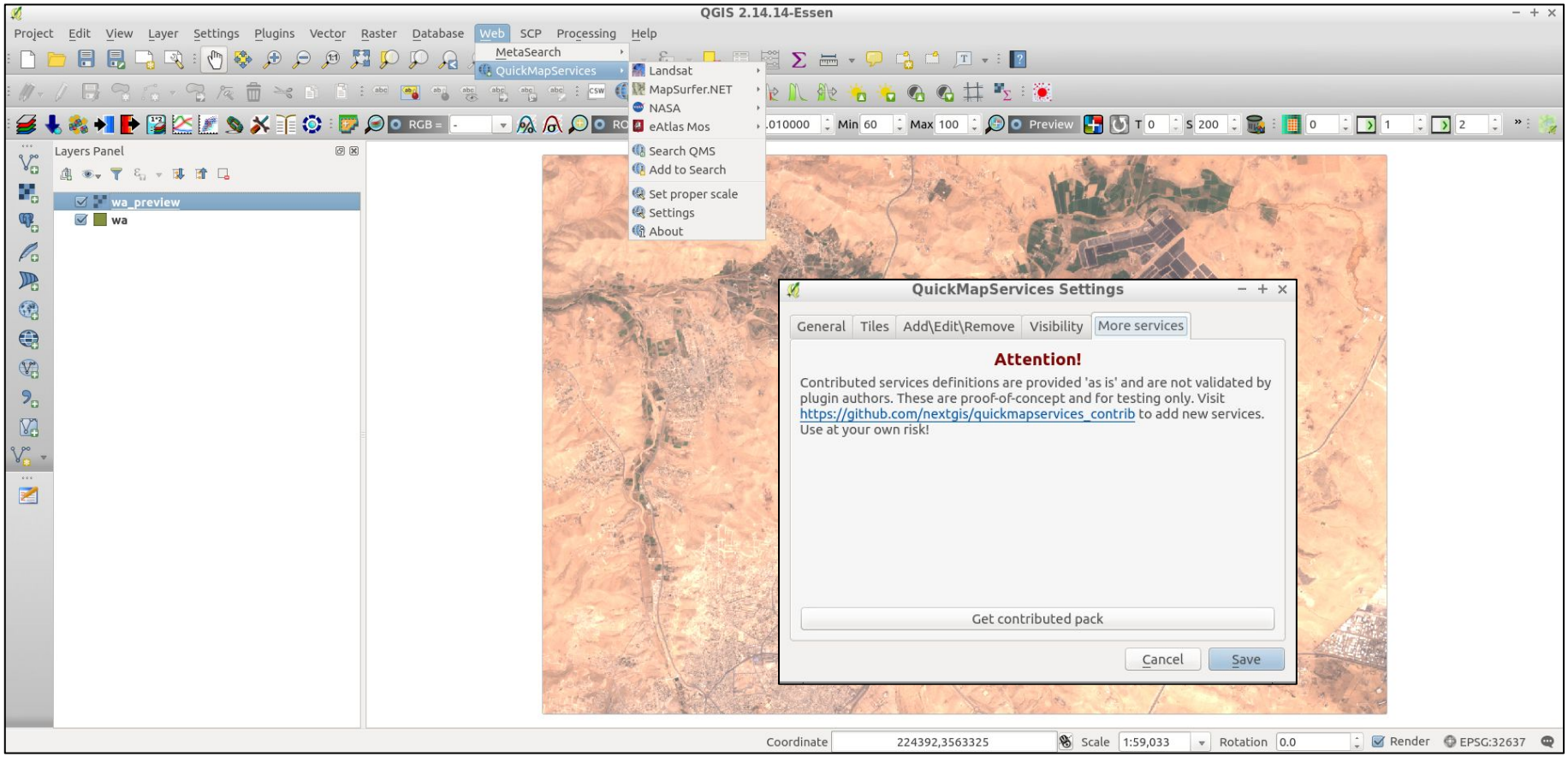
# Retrieve satellite images with QGIS: Basemaps

- ✓ Import into your QGIS the layers:
  - *wa.shp*
  - *wa_preview.tif*



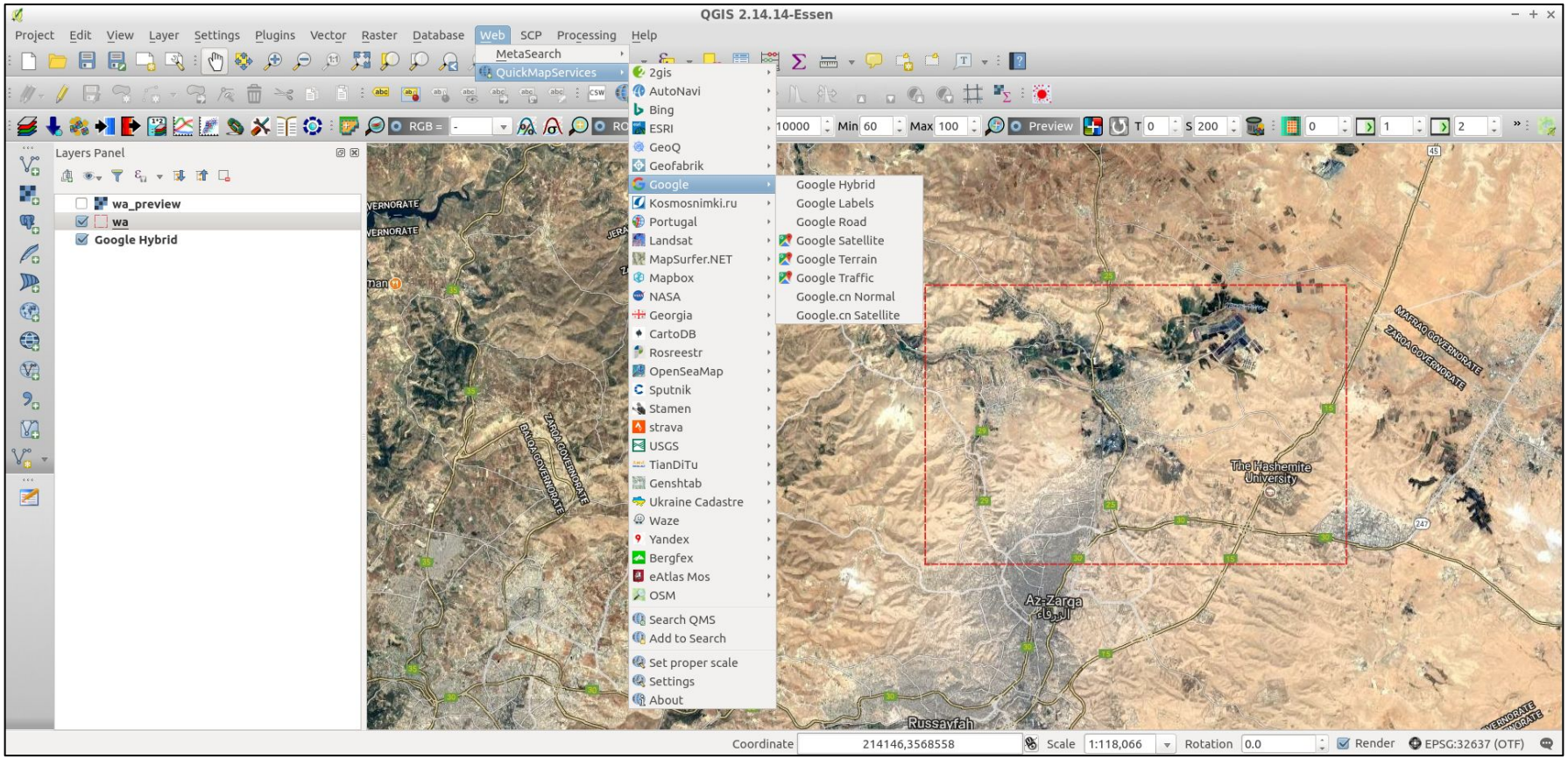
# Retrieve satellite images with QGIS: Basemaps

✓ On the Bar Menu select ***Web*** → ***QuickMapServices*** → ***Settings*** → ***More services*** → ***Get contributed pack*** to activate a richer collection of basemaps



# Retrieve satellite images with QGIS: Basemaps

✓ Select and activate a basemaps to better understand and contextualize the working area (wa) for this exercise

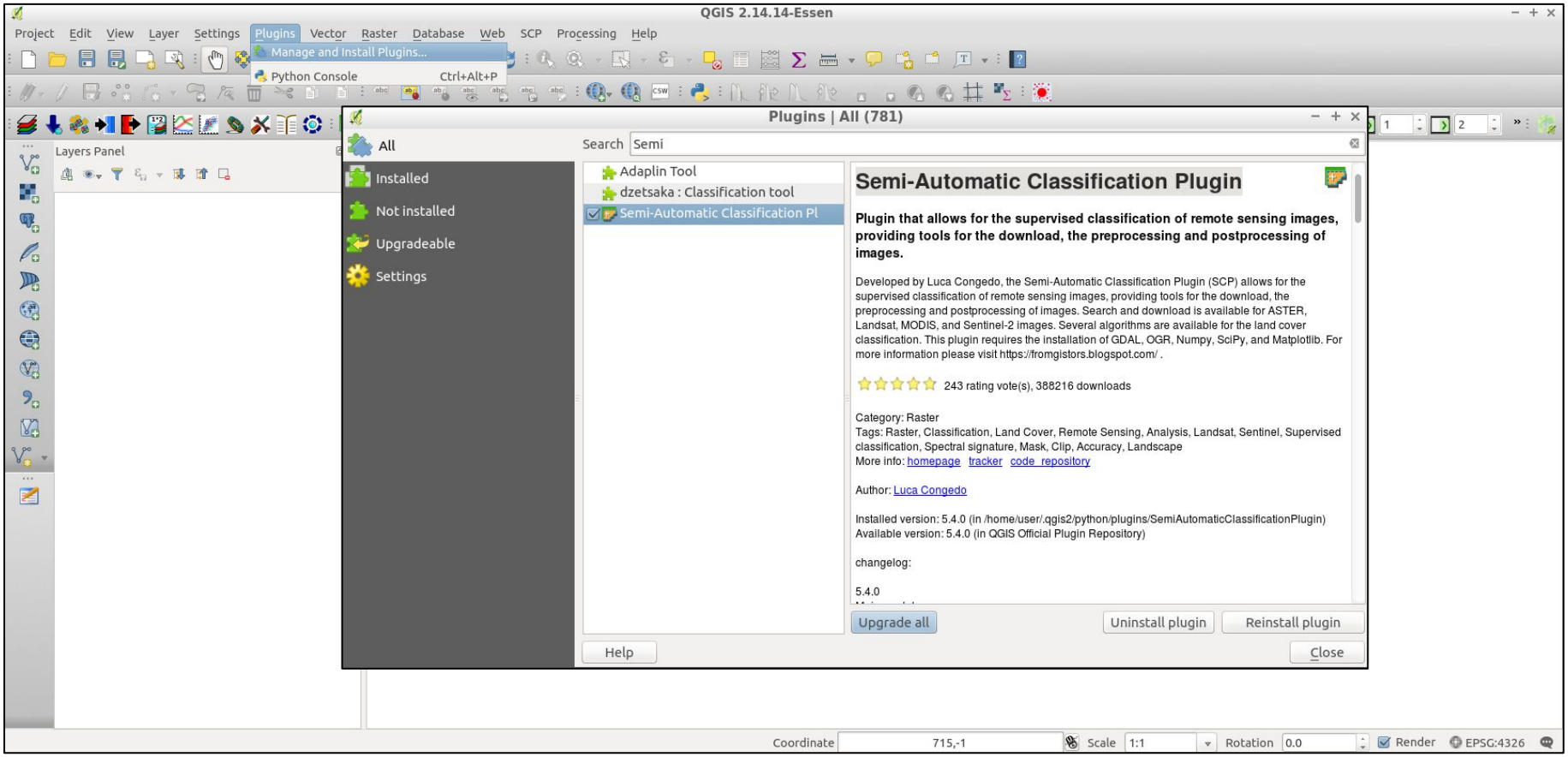


# Skills notebook

Activate basemaps from external providers for your QGIS project

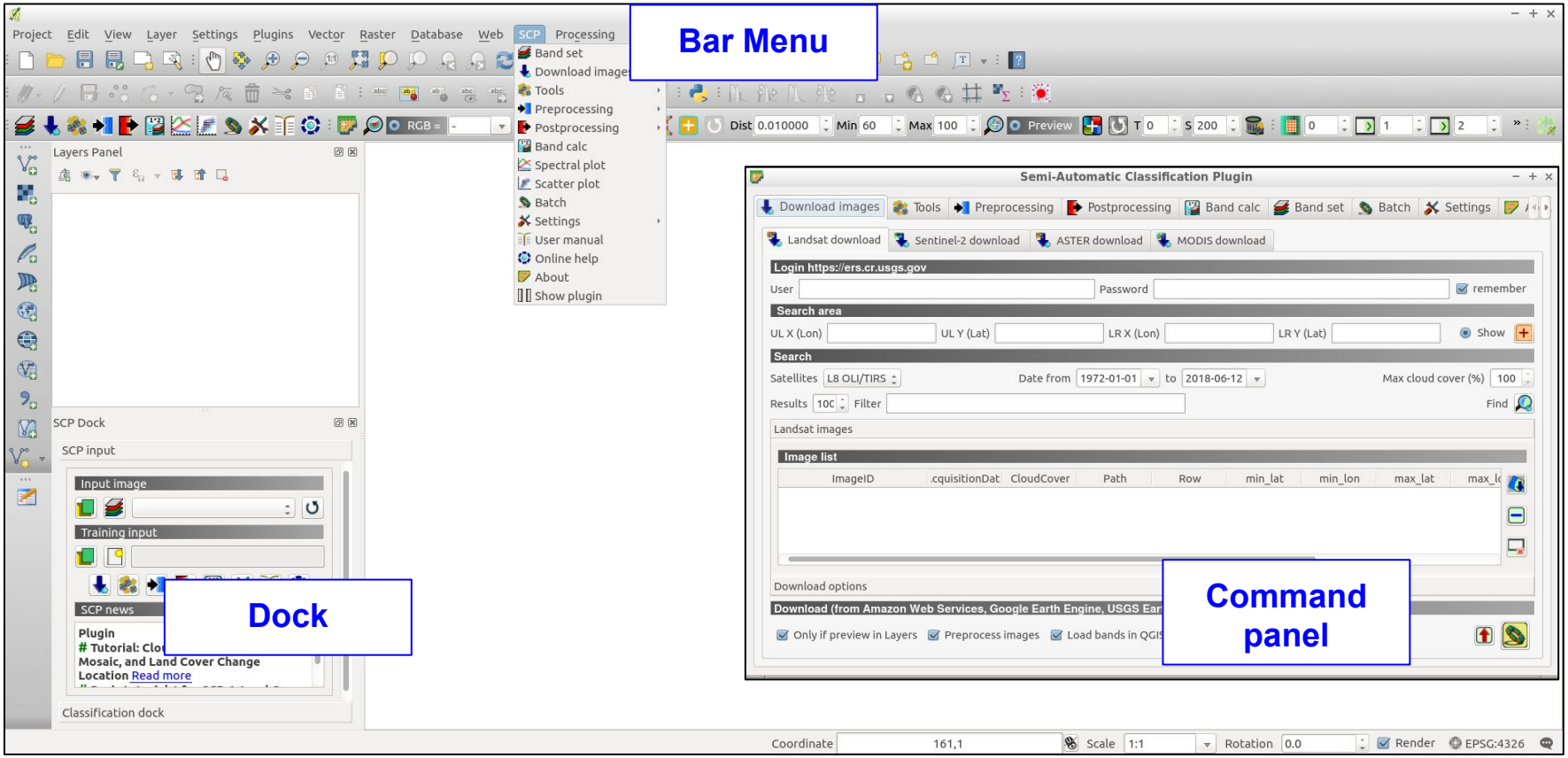
# Retrieve satellite images with QGIS: Open satellite imagery

✓ On the Bar Menu select ***Plugin*** → ***Menage and install Plugins*** to activate the ***Semi-Automatic Classification Plugin*** 



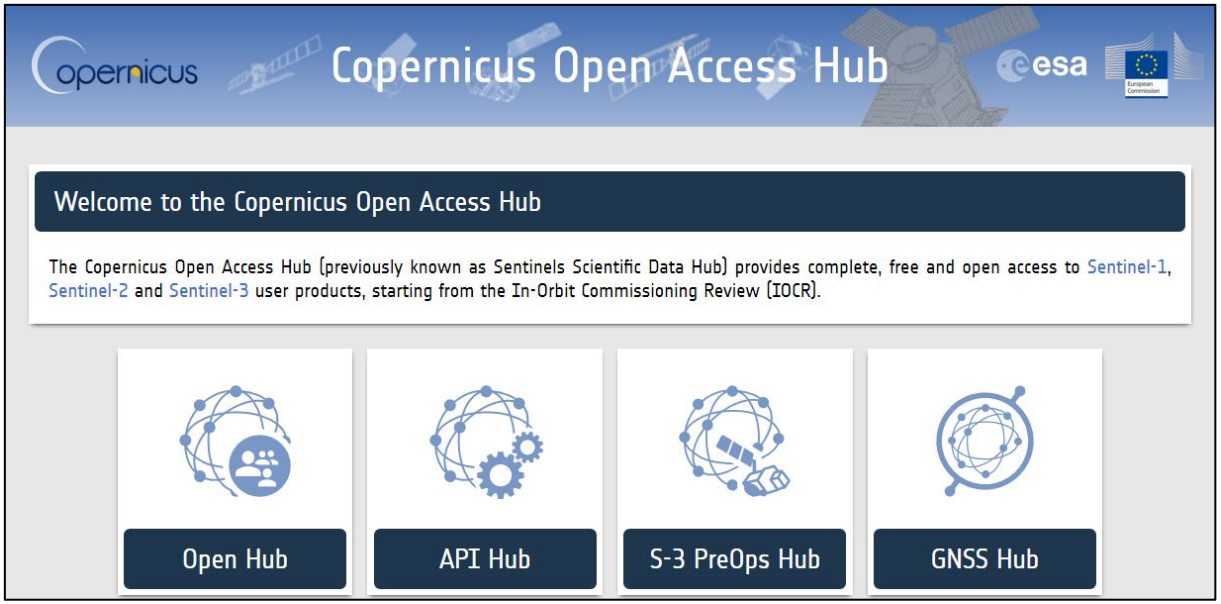
# Retrieve satellite images with QGIS: Open satellite imagery

✓ The ***Semi-Automatic Classification Plugin*** (SCP) is a free open source plugin for QGIS that allows for the semi-automatic classification (also supervised and unsupervised classification) of remote sensing images. It provides several tools for the download of free images (Landsat, Sentinel-2, Sentinel-3, ASTER, MODIS), the preprocessing of images, the postprocessing of classifications, and the raster calculation



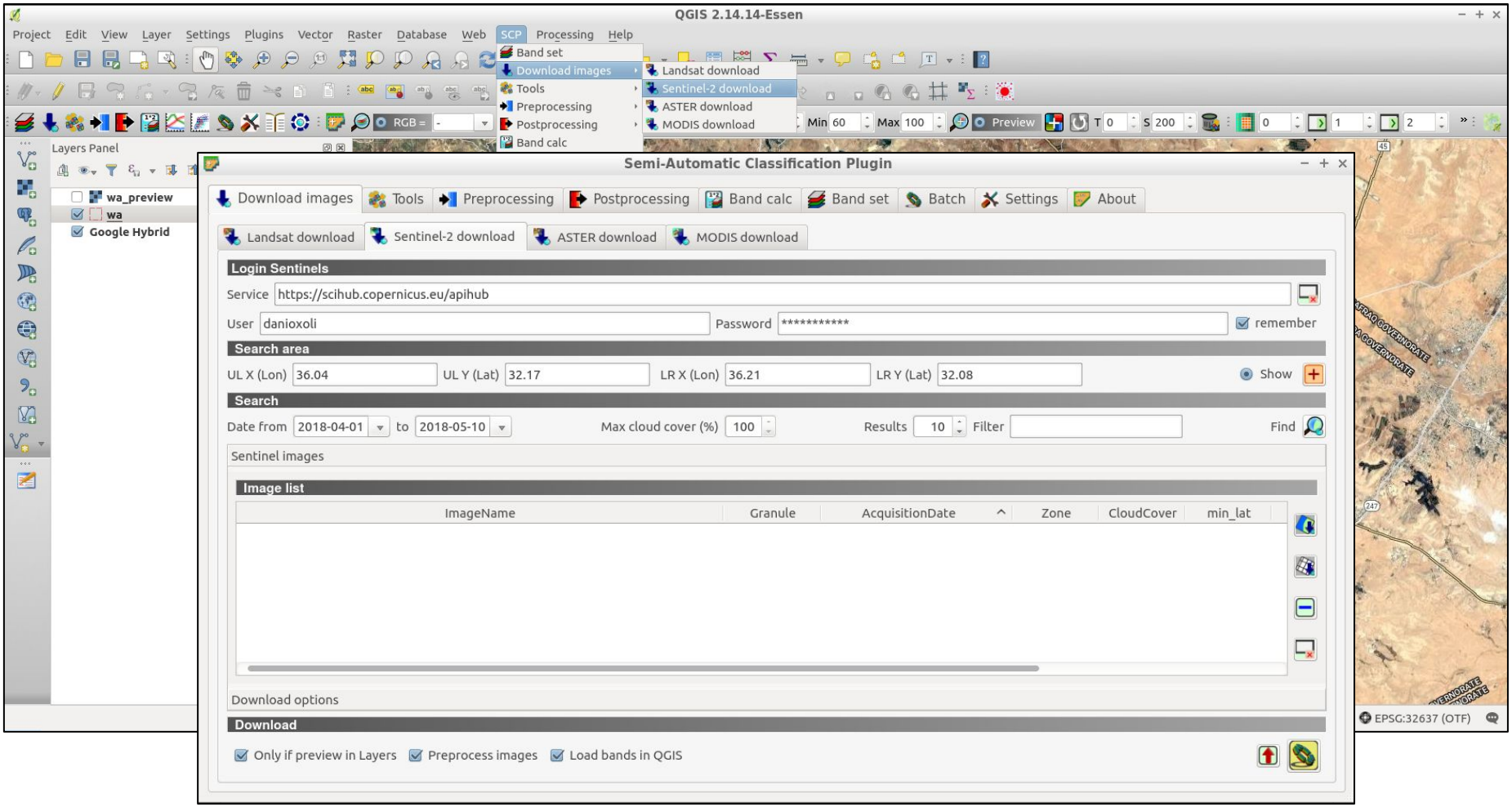
# Retrieve satellite images with QGIS: Open satellite imagery

- ✓ We are going to query and browse the data catalogue of the ESA Sentinel-2 mission. This is enabled by the Copernicus Open Access Hub which provides developers and data users with a set of API to access the imagery catalogue
- ✓ The API is implemented within the SCP Plugin by enabling the access to Sentinel-2 imagery data (and many others) directly from QGIS
- ✓ Users must be authenticated to access these services. You can create your personal account at any time here (*not compulsory for this exercise*)



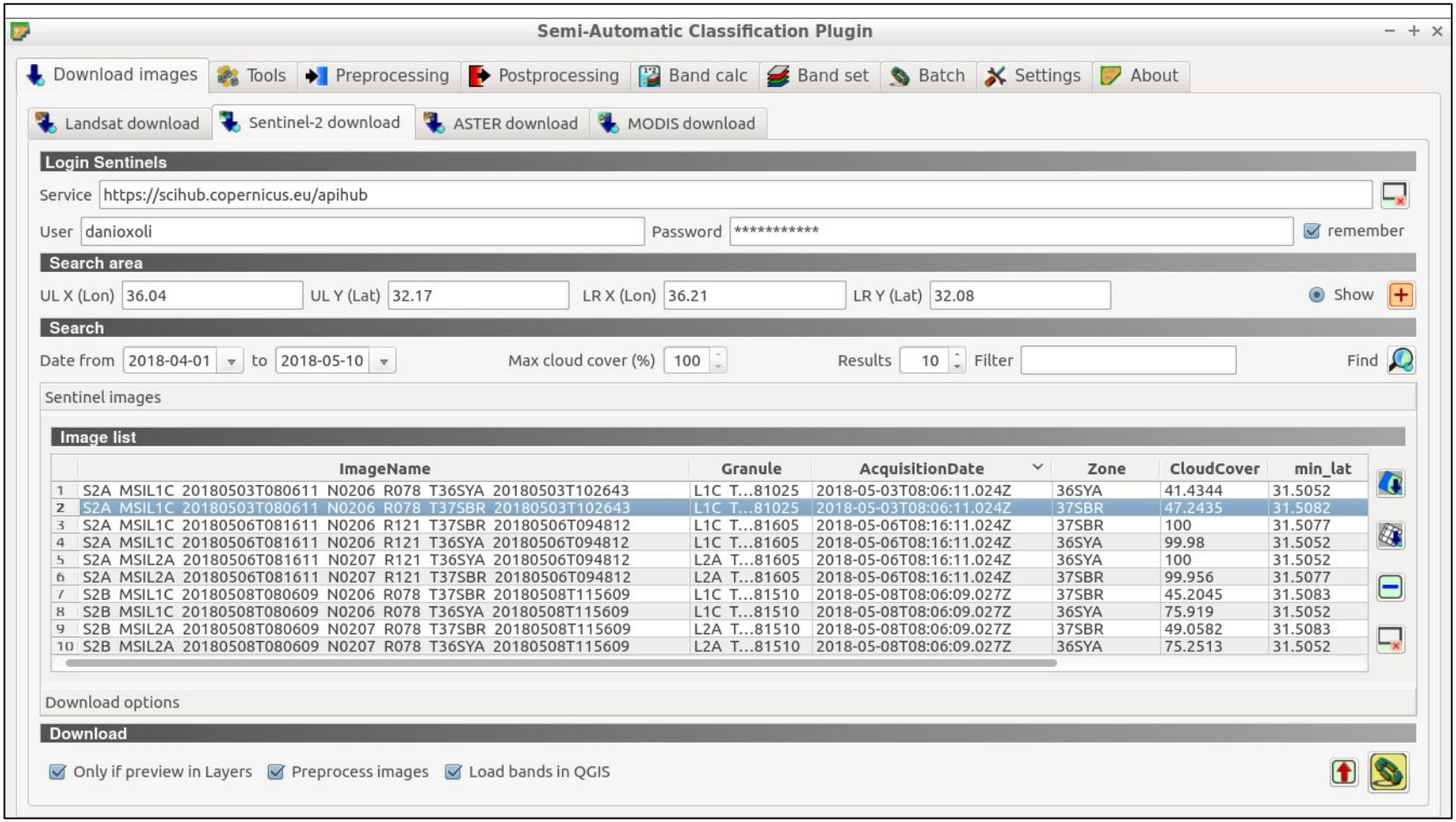
# Retrieve satellite images with QGIS: Open satellite imagery

✓ On the Bar Menu select ***SCP*** → ***Download Images*** → ***Sentinel-2 download***. Insert the Login information and specify the Search area and date. To run the Search press 



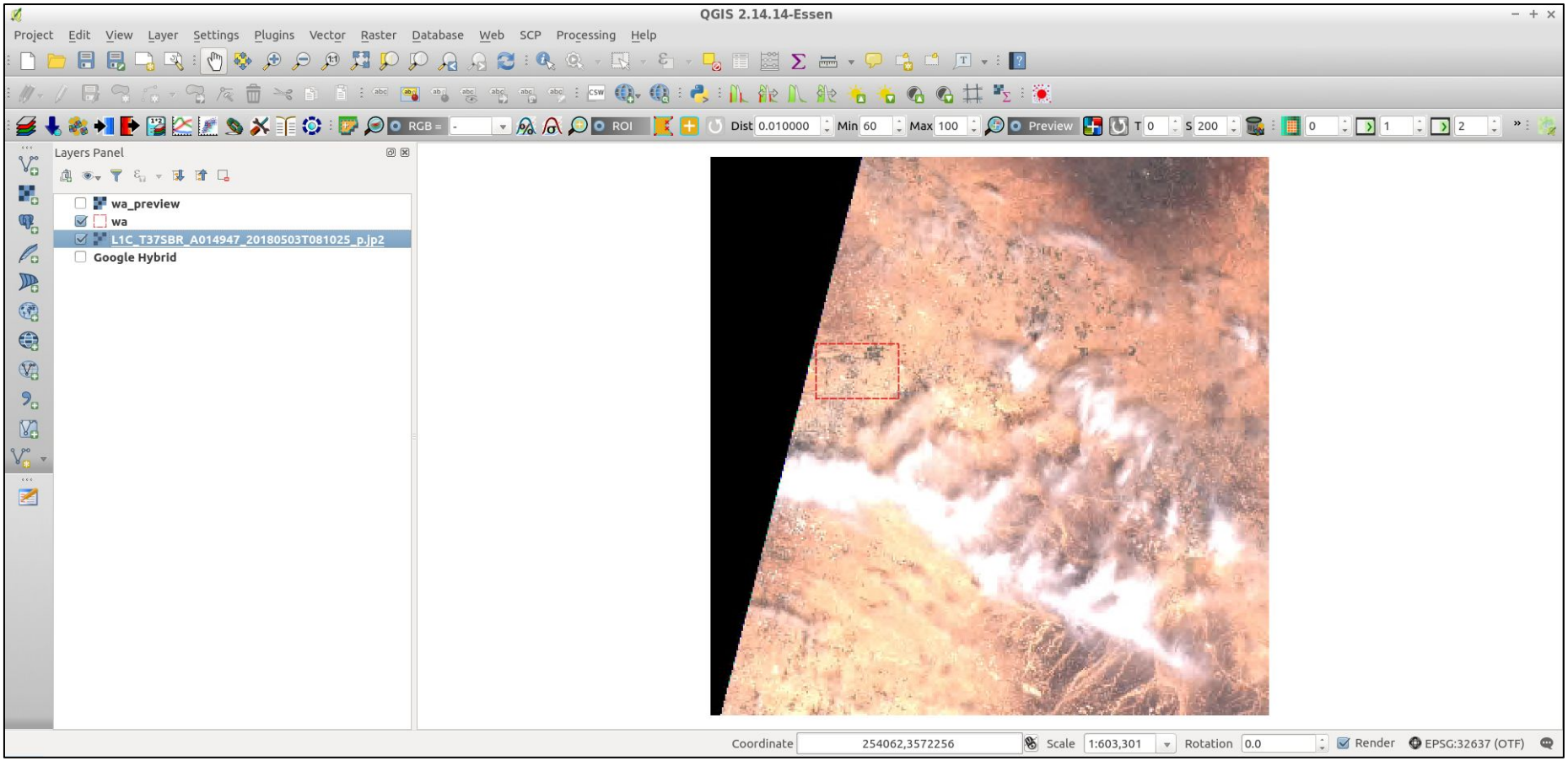
# Retrieve satellite images with QGIS: Open satellite imagery

✓ The images list is now downloaded. Select the image of your interest (*see the ImageName selected in the figure*). Press  to preview the selected image in the QGIS Map panel



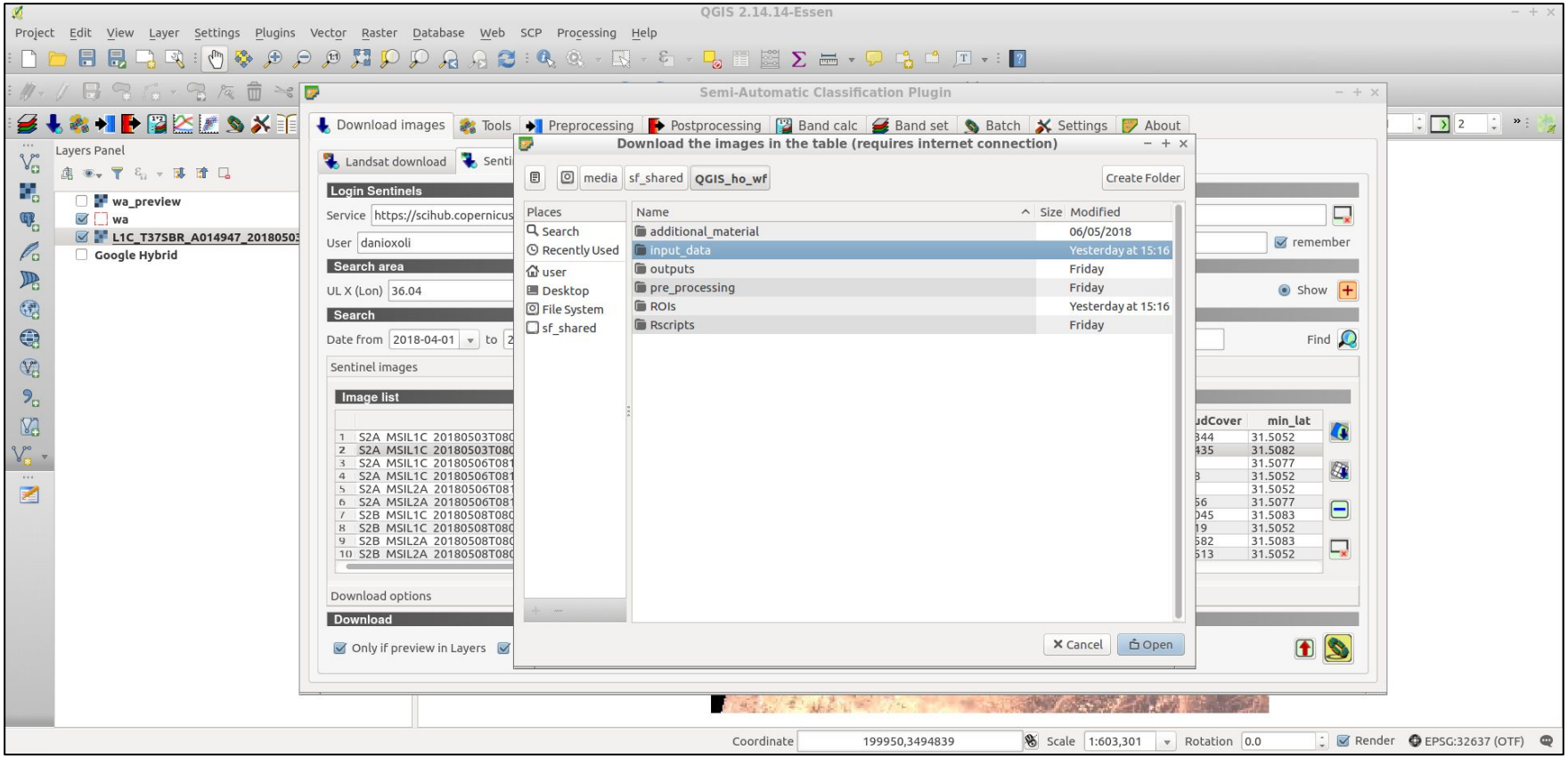
# Retrieve satellite images with QGIS: Open satellite imagery

✓ The selected image is previewed to your QGIS project



# Retrieve satellite images with QGIS: Open satellite imagery

- ✓ To download and save the selected image press 
- ✓ The image bands will be automatically imported in your QGIS project as *.tif* layers and the directory containing the whole Sentinel-2 imagery (*.SAFE*) will be save into your local memory (*the imagery directory for this exercise is available at: QGIS_ho_wf -> input_data*)

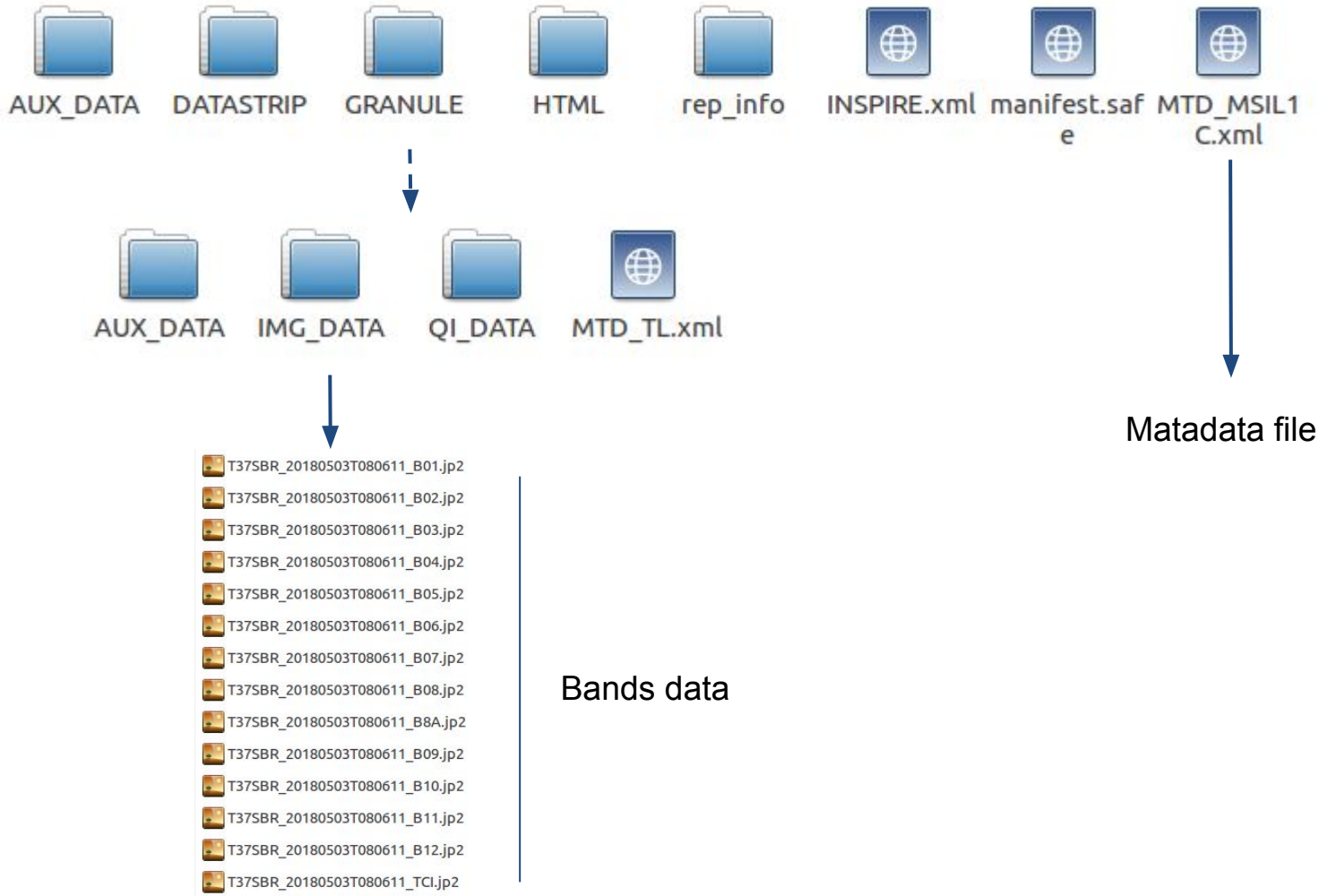


# Skills notebook

- [x] Activate basemaps from external providers for your QGIS project
- [x] Search and download satellite imagery data from QGIS

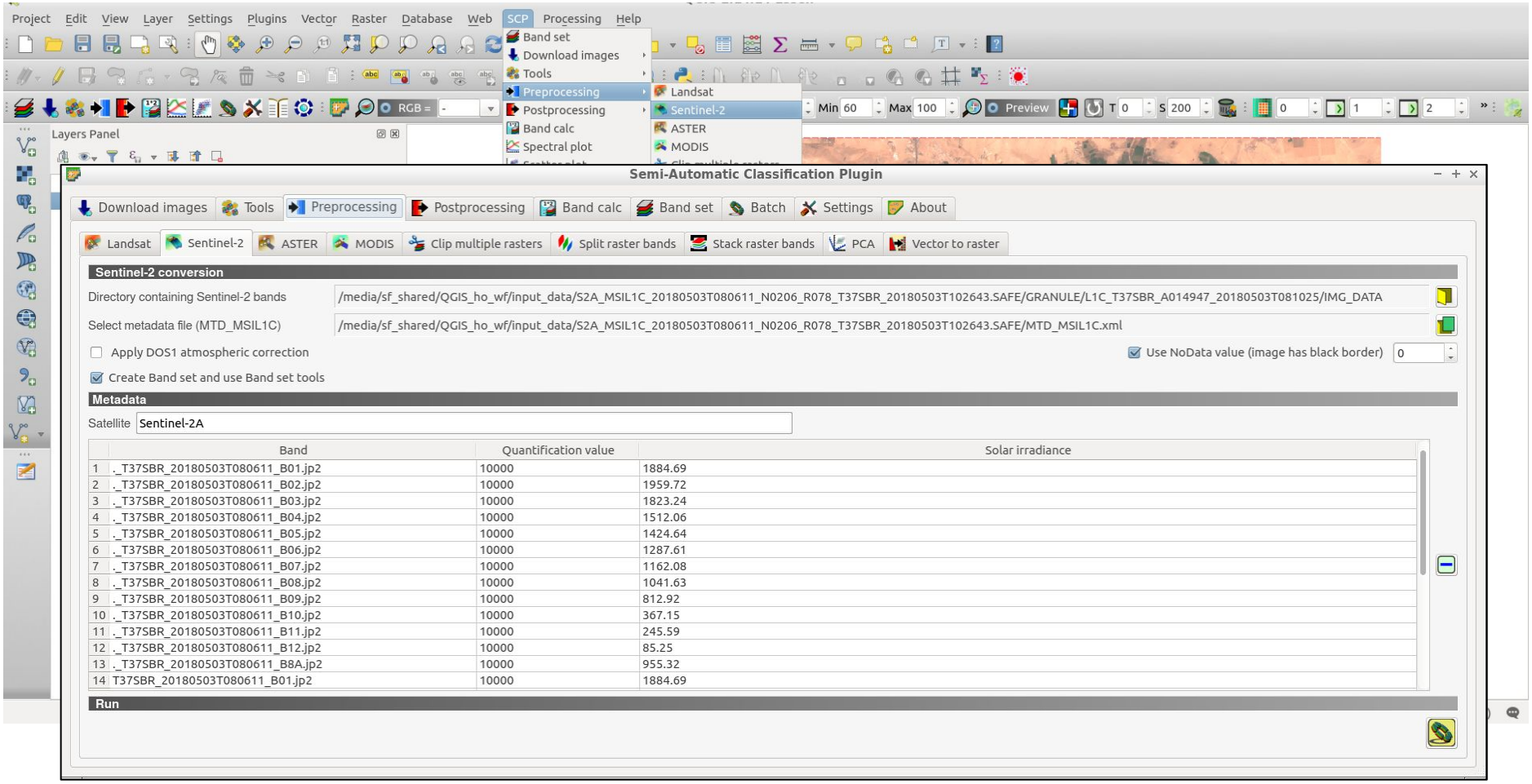
# Satellite images preprocessing: Import bands + atmospheric correction

✓ The Sentinel-2 imagery directory



# Satellite images preprocessing: Import bands + atmospheric correction

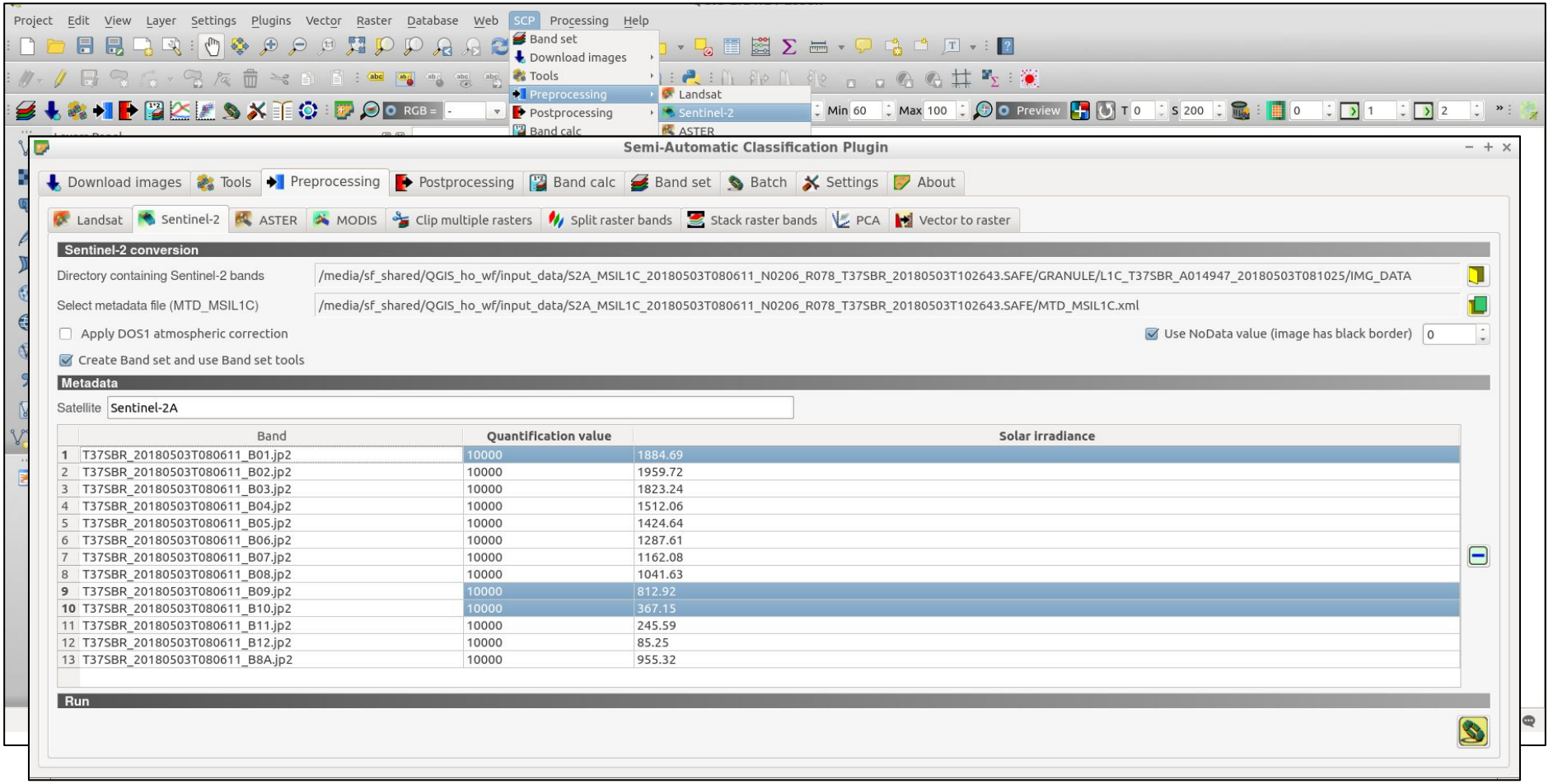
✓ On the Bar Menu select ***SCP*** → ***Preprocessing*** → ***Sentinel 2***. Enter the directory containing the *Bands data* and the *Metadata file*



# Satellite images preprocessing: Import bands + atmospheric correction

✓ Select Bands 1, 9, 10 and remove them from the list by clicking on 

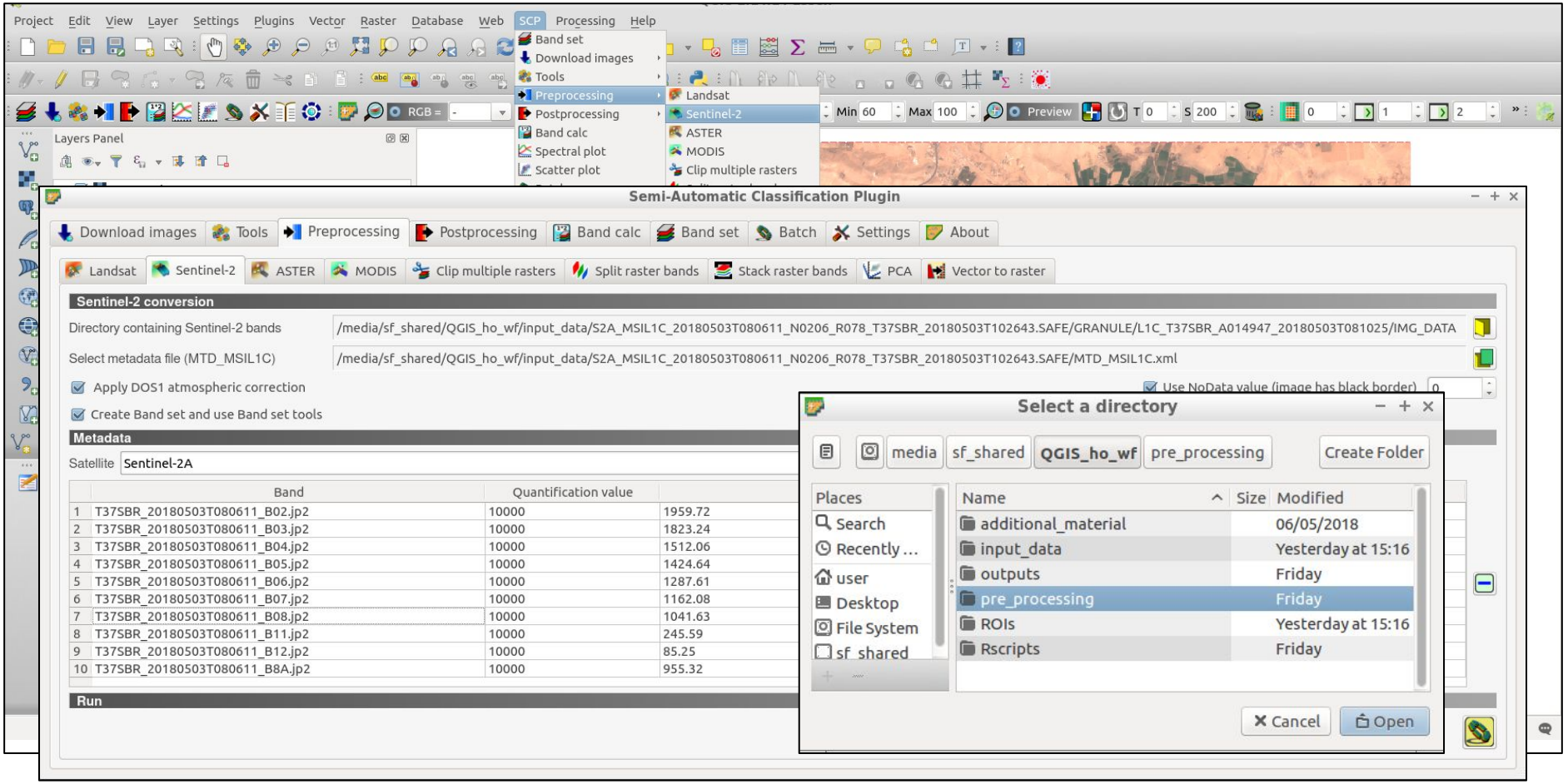
✓ These Bands (60m) will not be considered later for this exercise



# Satellite images preprocessing: Import bands + atmospheric correction

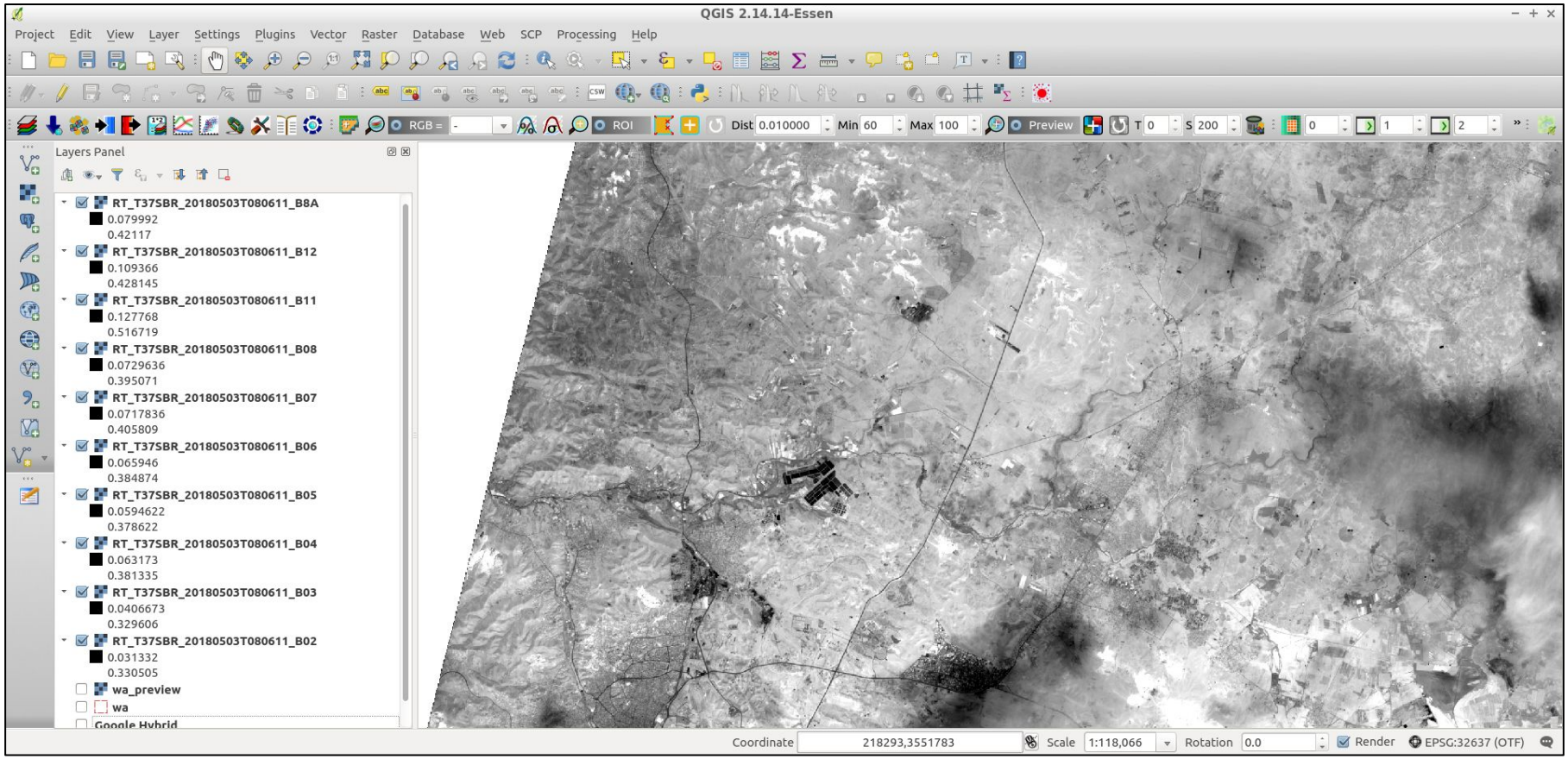
✓ Check the box ***Apply DOS1 atmospheric correction*** and press  to start the preprocessing

✓ *This might take several minutes*



# Satellite images preprocessing: Import bands + atmospheric correction

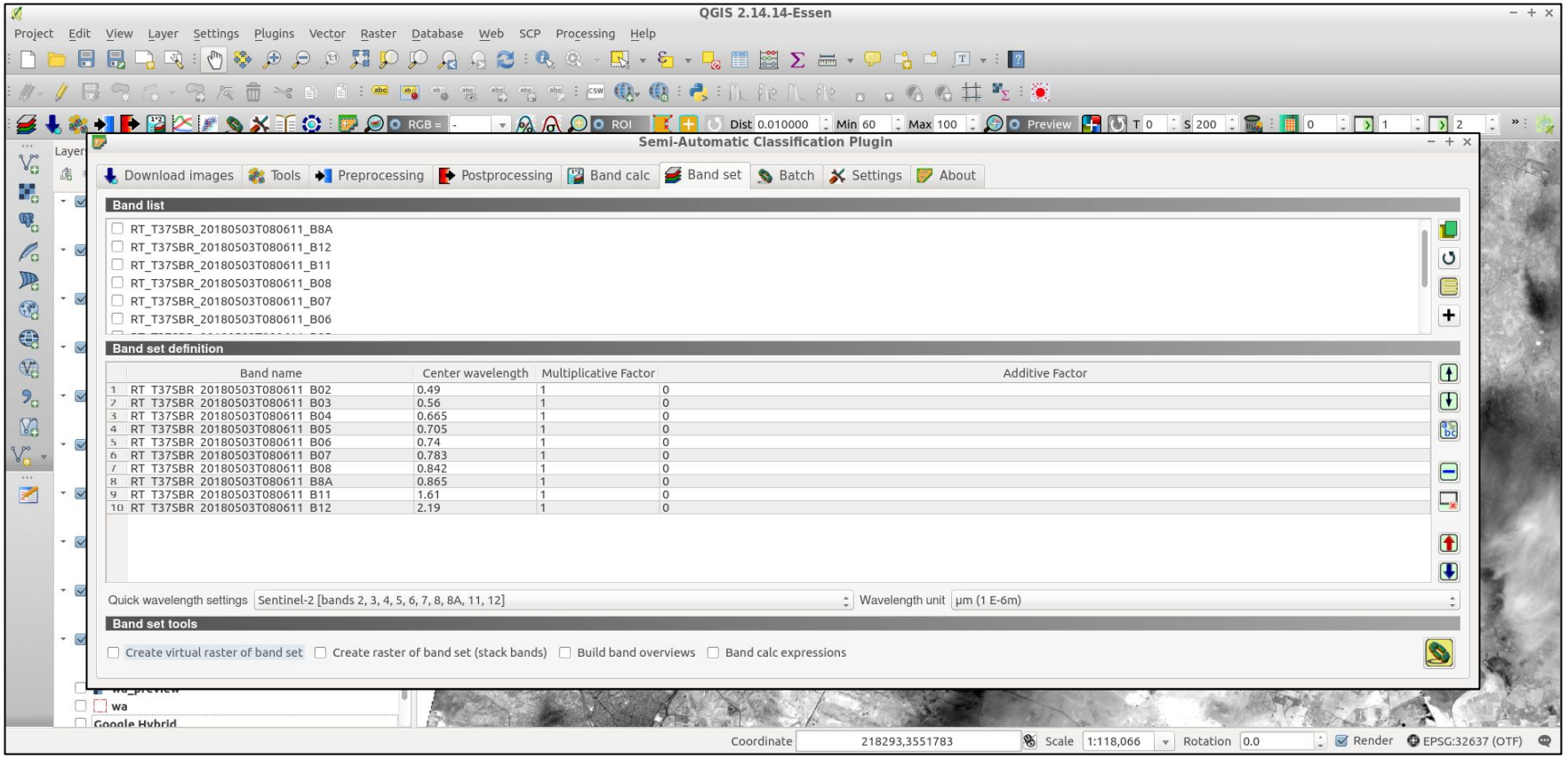
✓ The Bands are preprocessed (.tif formatting + surface reflectance adjustment), saved into your local memory, and imported in your QGIS project (with the “RT_” prefix)



# Satellite images preprocessing: Band set

✓ To create a composite raster (multispectral imagery) of your scene, first you need to define a ***Band set*** specifying an order to stack the selected band data in the composite raster

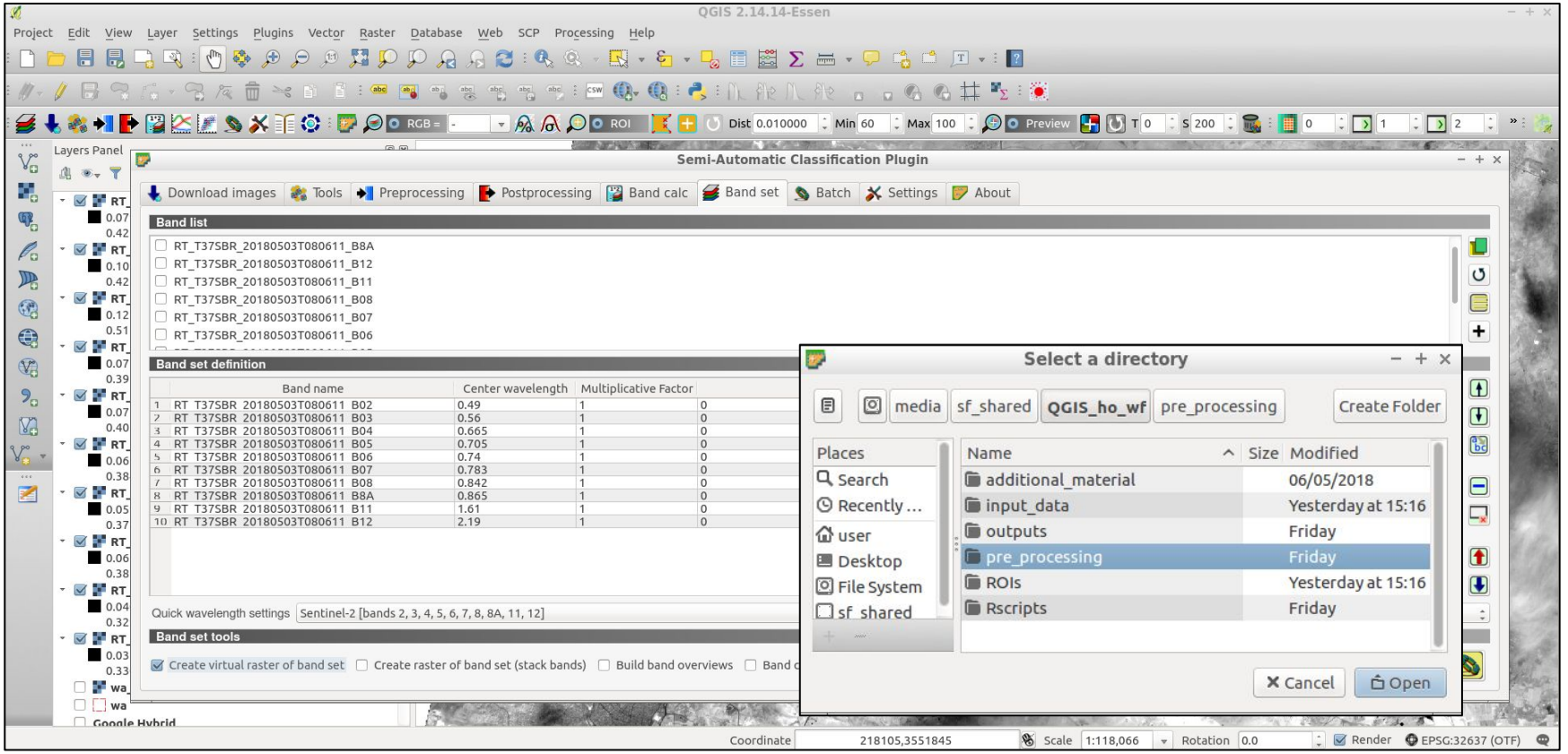
✓ On the Bar Menu select ***SCP*** → ***Band set*** . Load and order all the bands (*as shown in the figure*). Activate the option ***Quick wavelength settings*** → ***Sentinel 2*** to automatically set the center wavelengths



# Satellite images preprocessing: Virtual raster

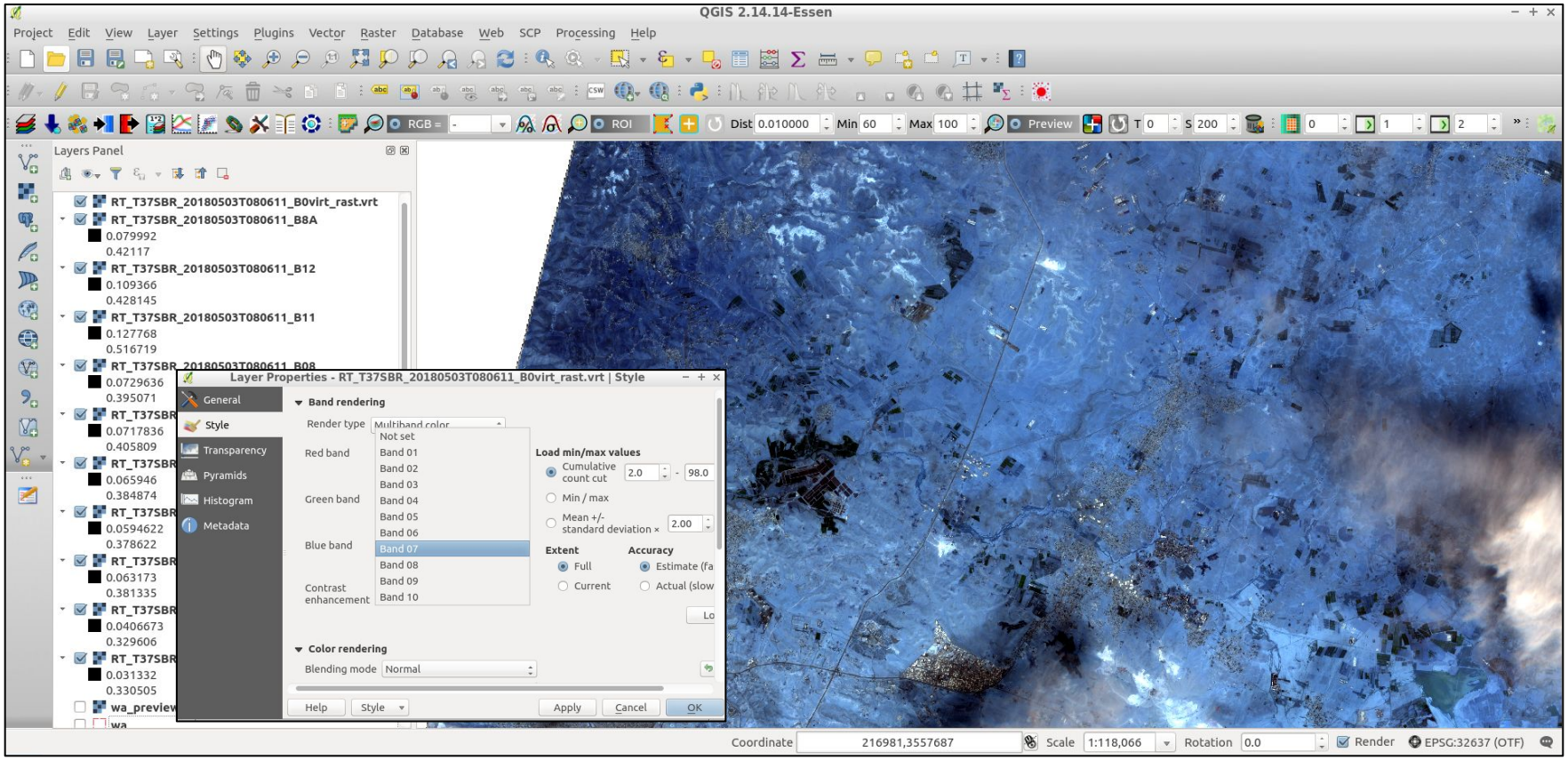
✓ A clever way of saving “by-product” raster layers is the Virtual Raster format (*.vrt*). It consists of a text file pointing on multiple raster datasets which can be read and manipulated as a single layer

✓ Check the box ***Create a virtual raster of band set*** and press  to create a composite (multispectral) raster from your raster Bands according to the defined ***Band set***.



# Satellite images preprocessing: Virtual raster

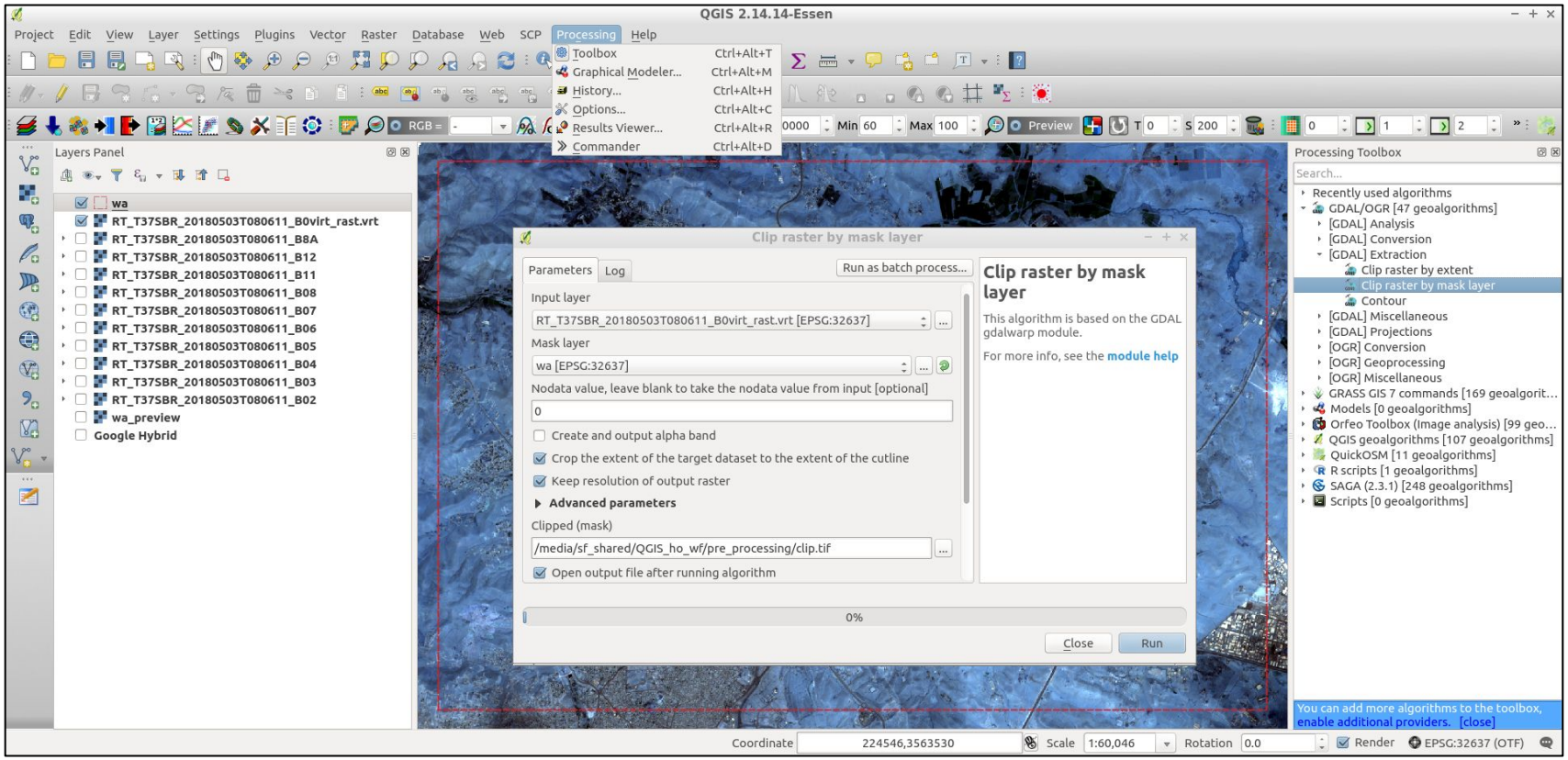
✓ The Virtual raster (*.vrt*) is saved into your local memory and imported in your QGIS project



# Satellite images preprocessing: Clip

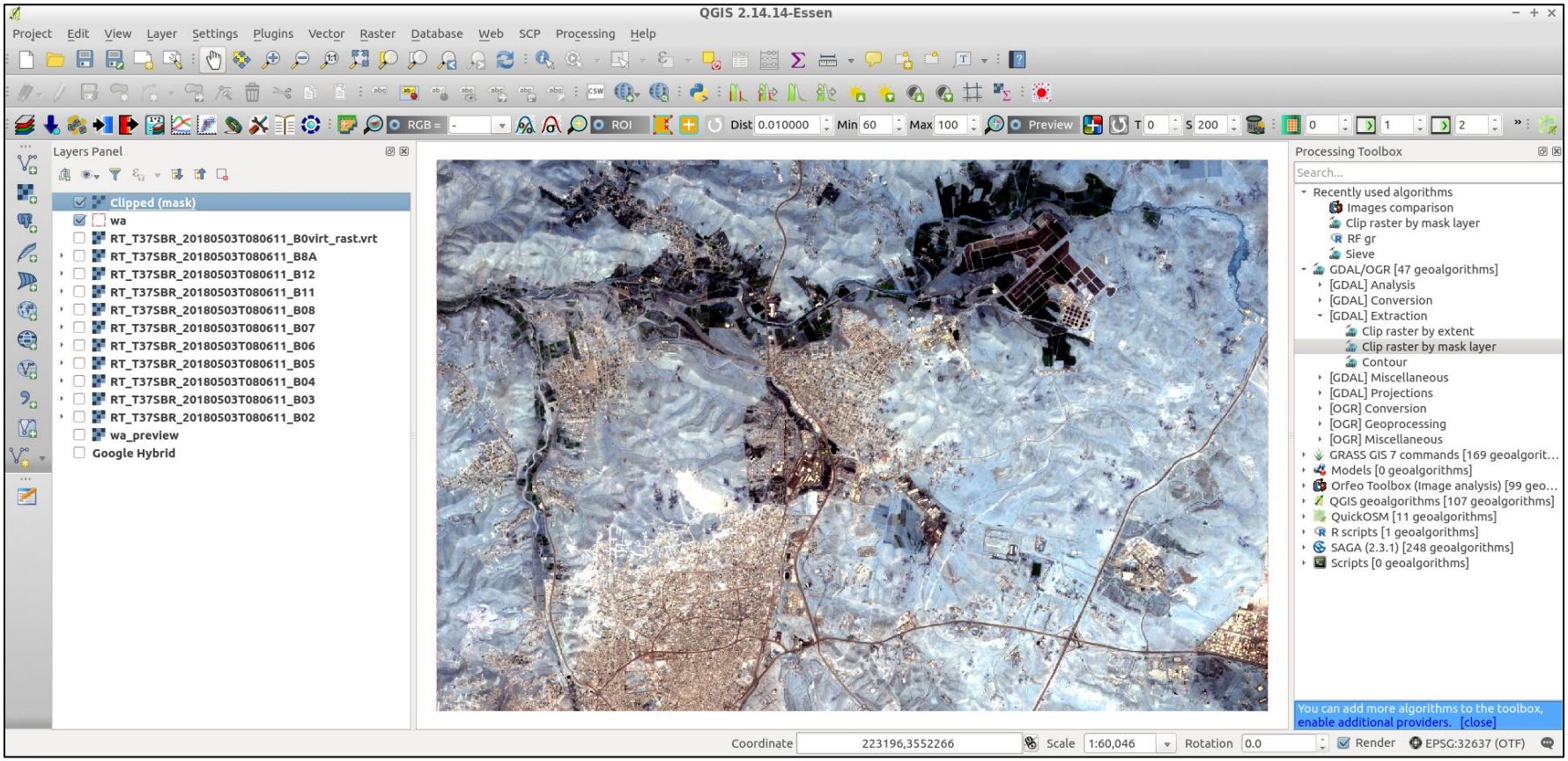
✓ To obtain a composite raster layer covering only the working area, thus preventing further processing on the full raster layer (i.e. save time!), we can ***Clip*** the full Virtual raster layer on a region of interest and save the results as a "real" layer (.tif)

✓ On the Bar Menu activate the ***Processing Toolbox***. Here, look for ***GDAL*** → ***Extraction*** → ***Clip a raster by mask layer***. Define the parameter for the clipping task (*as shown in the figure*) and press ***Run***



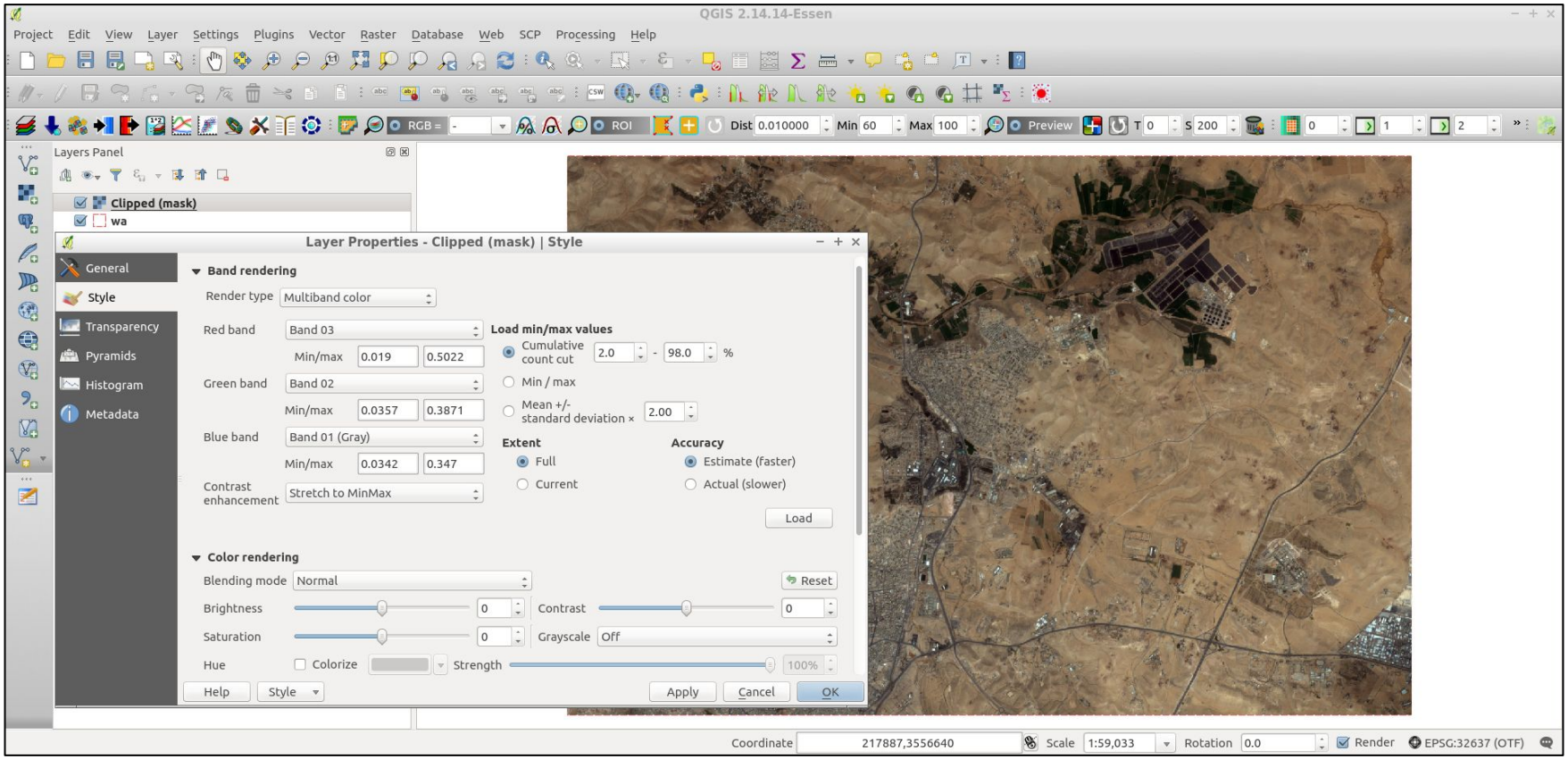
# Satellite images preprocessing: Clip

✓ The clipped raster layer (*.tif*) is saved into your local memory and imported in your QGIS project (*this will be used later to perform a supervised classification*)



# Satellite images preprocessing: Styling a multispectral raster layer

✓ To define a style for a multispectral image, open the layer ***Properties*** → ***Style***→ ***Multiband Color*** and specify the Bands you want to visualize. According to the Sentinel-2 imagery and our ***Band set***, to obtain a natural color view (i.e. RGB), set the bands as shown in the figure. (*Hints*: for a better visualization, use the command ***Local Histogram Stretch*** )



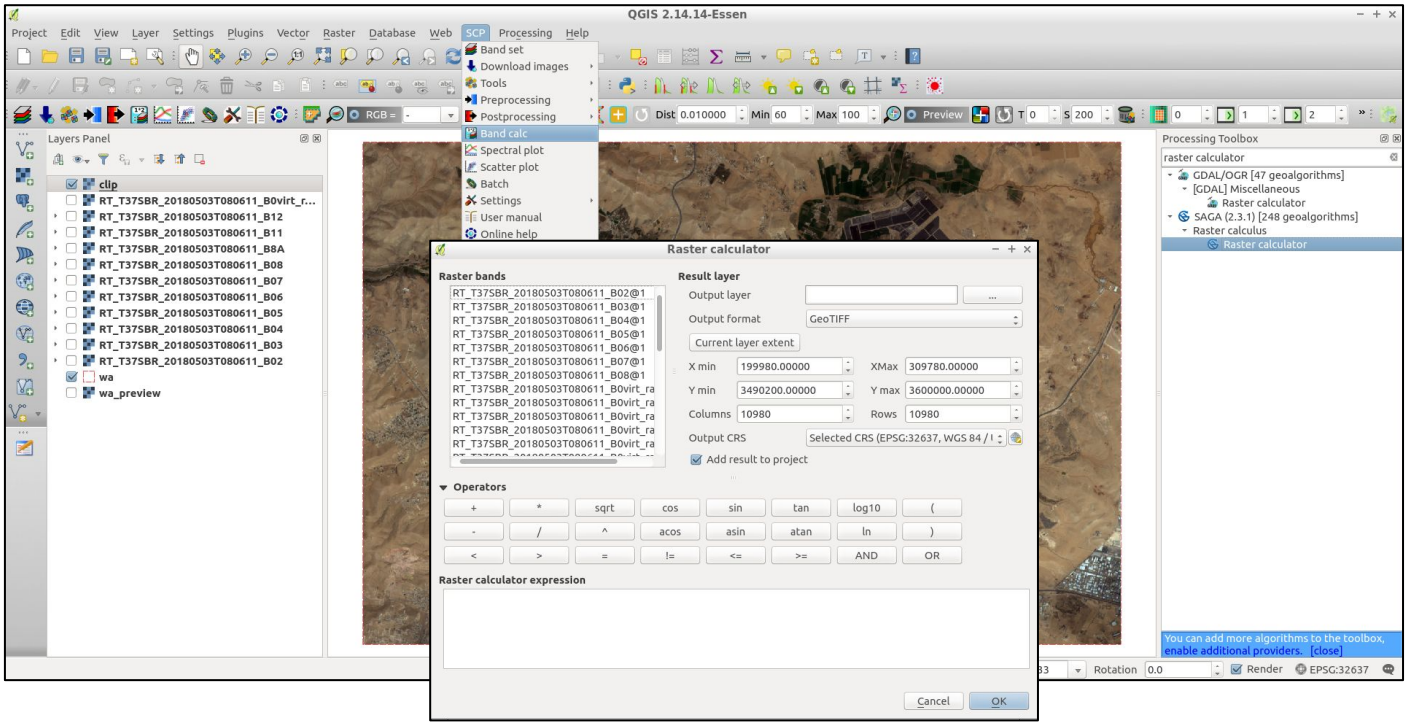
# Skills notebook

- [x] Activate basemaps from external providers for your QGIS project
- [x] Search and download satellite imagery data from QGIS
- [x] Full preprocessing of multispectral satellite imagery with QGIS using both Plugins and Processing algorithms

# Raster calculator

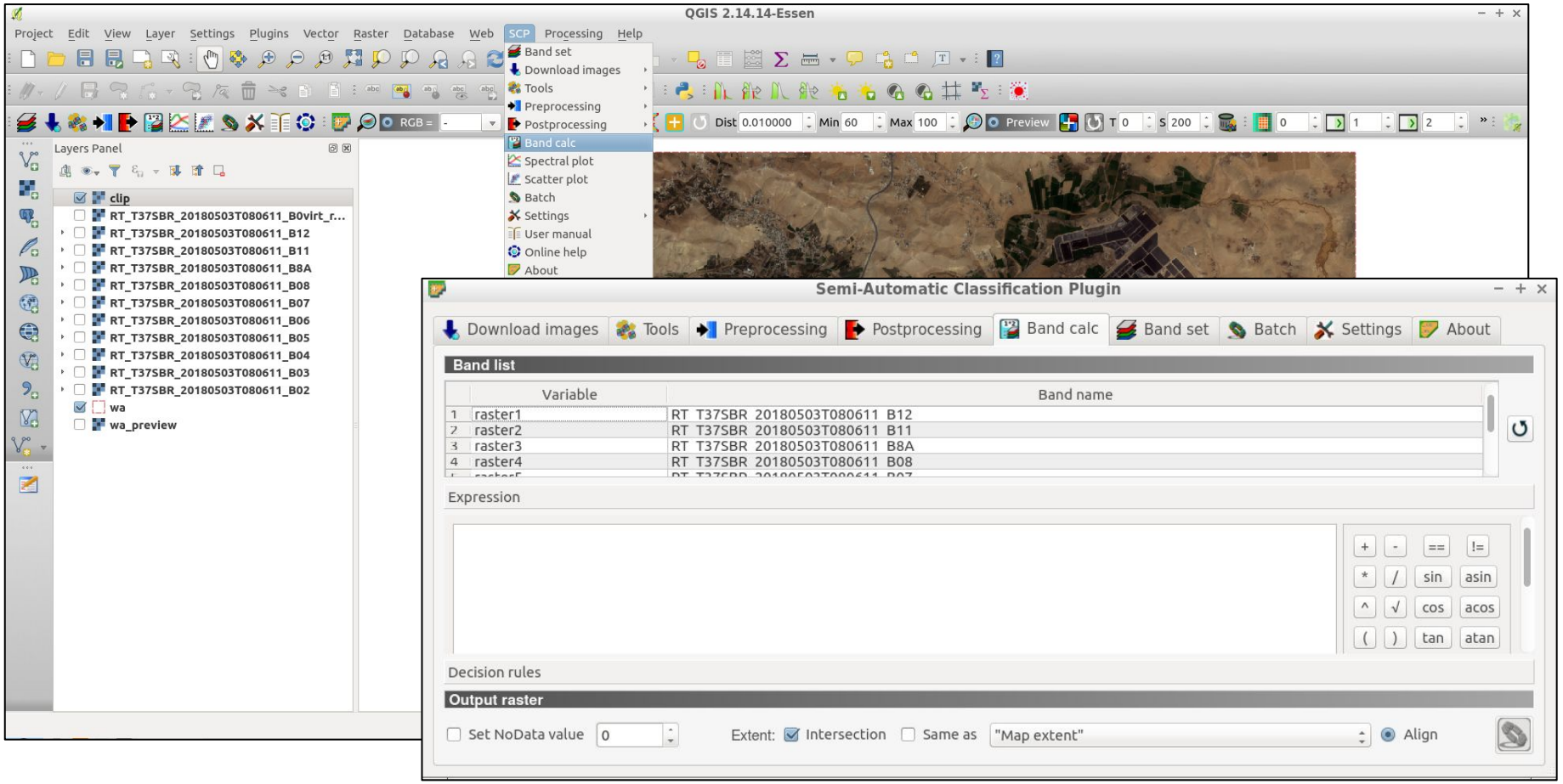
- ✓ The Raster Calculator allows you to perform calculations on the basis of existing raster pixel values

- ✓ QGIS provides with different solutions for performing raster calculus, e.g.:
  - **QGIS (core)** ***Raster calculator***
  - GDAL Raster calculator
  - SAGA GIS Raster calculator
  - **SCP** ***Band calc***



# Raster calculator: The SCP Band calc

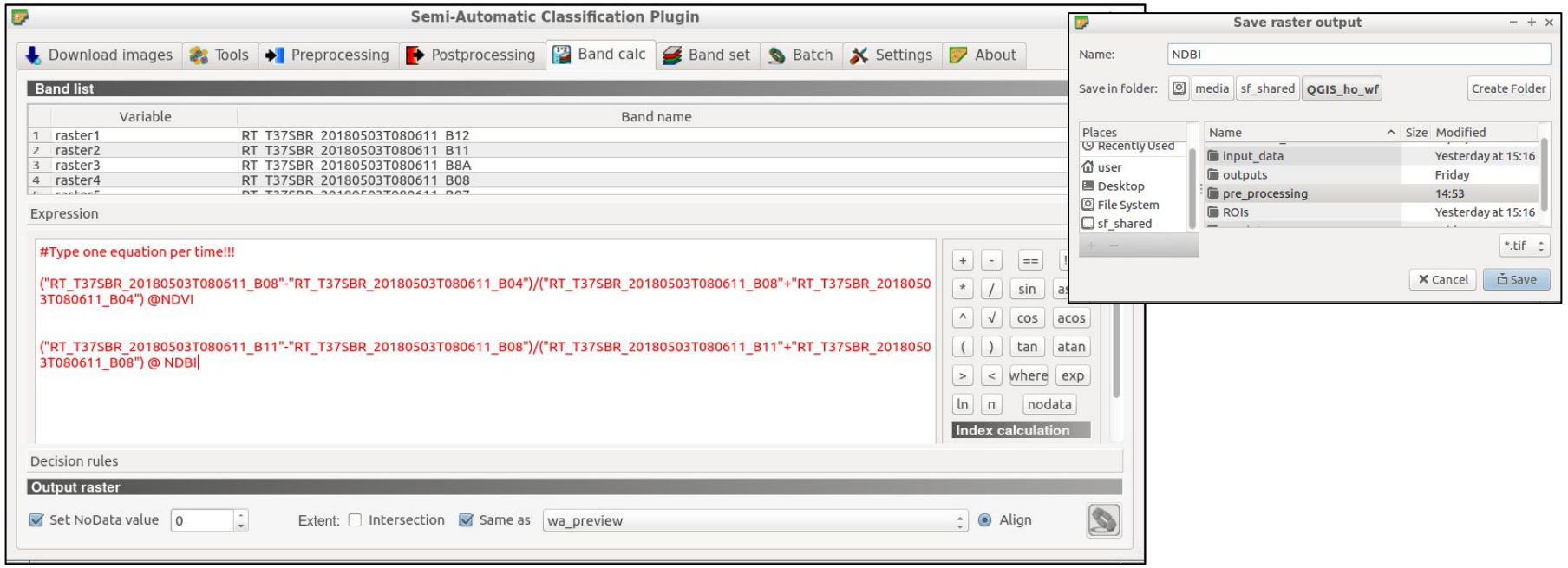
✓ On the Bar Menu select ***SCP*** → ***Band calc***. Refresh the bands list by clicking ↺



# Raster calculator: The SCP Band calc

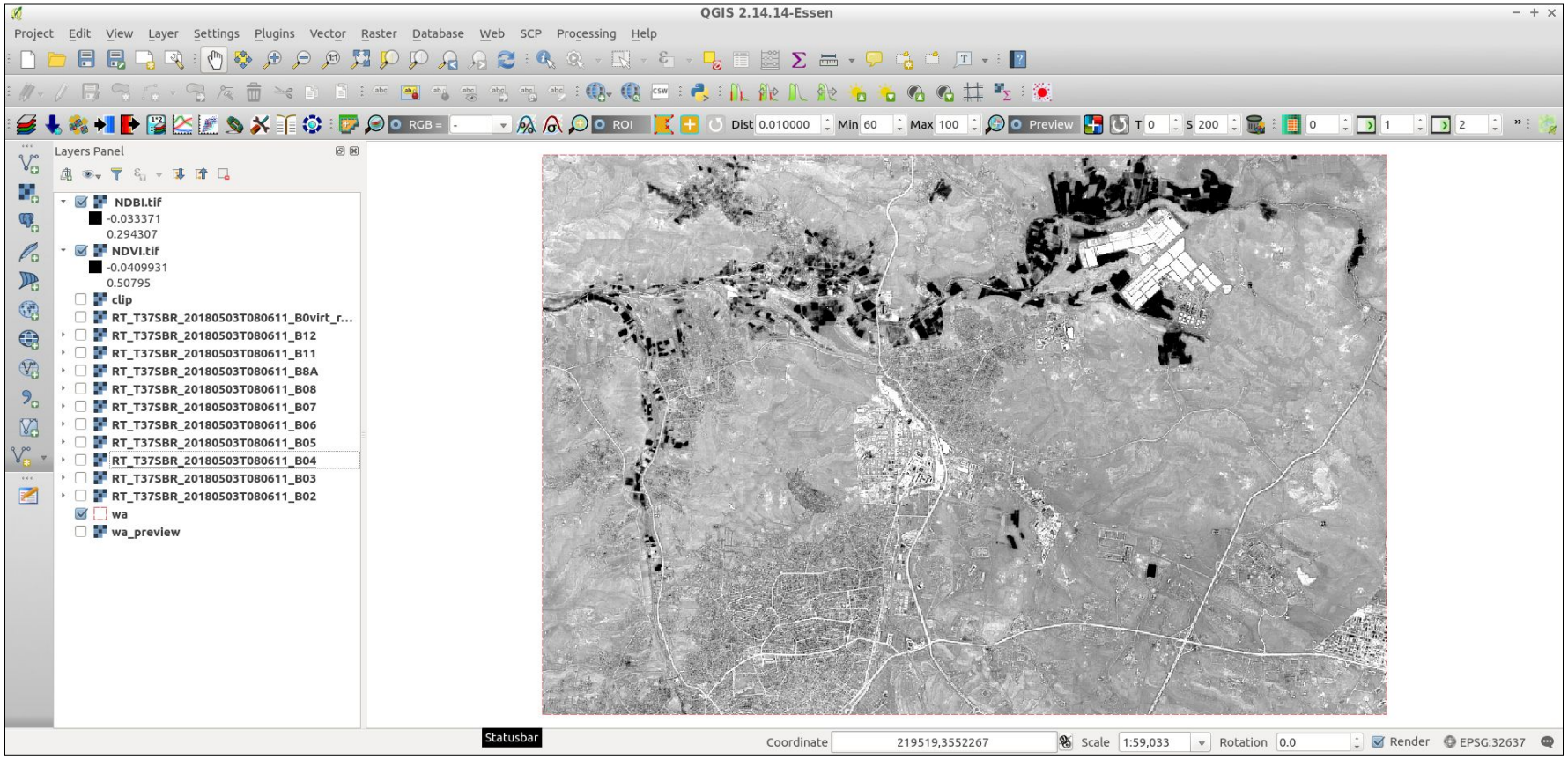
- ✓ Let's compute now simple graphical indicators that can be used to analyze remote sensing data, namely:
  - The **Normalized Difference Vegetation Index** (NDVI). The NDVI is the most well known and used vegetation index. It is a simple, but effective for quantifying green vegetation. The NDVI normalizes green leaf scattering in the near-infrared wavelength and chlorophyll absorption in the red wavelength [eq: **(B8 - B4) / (B8 + B4)**]
  - The **Normalized Difference Built-up Index** (NDBI). The NDBI highlights urban areas with higher reflectance in the shortwave-infrared (SWIR) region, compared to the Near Infrared (NIR) region [eq: **(B11 - B8) / (B11 + B8)**]

- ✓ On the ***SCP*** → ***Band calc*** . Type the equations (*see the figure*), select the option ***Extent*** → ***Same as*** → *wa_preview* (to compute automatically the output on the working area only), and define an output folder for the raster layer



# Raster calculator: The SCP Band calc

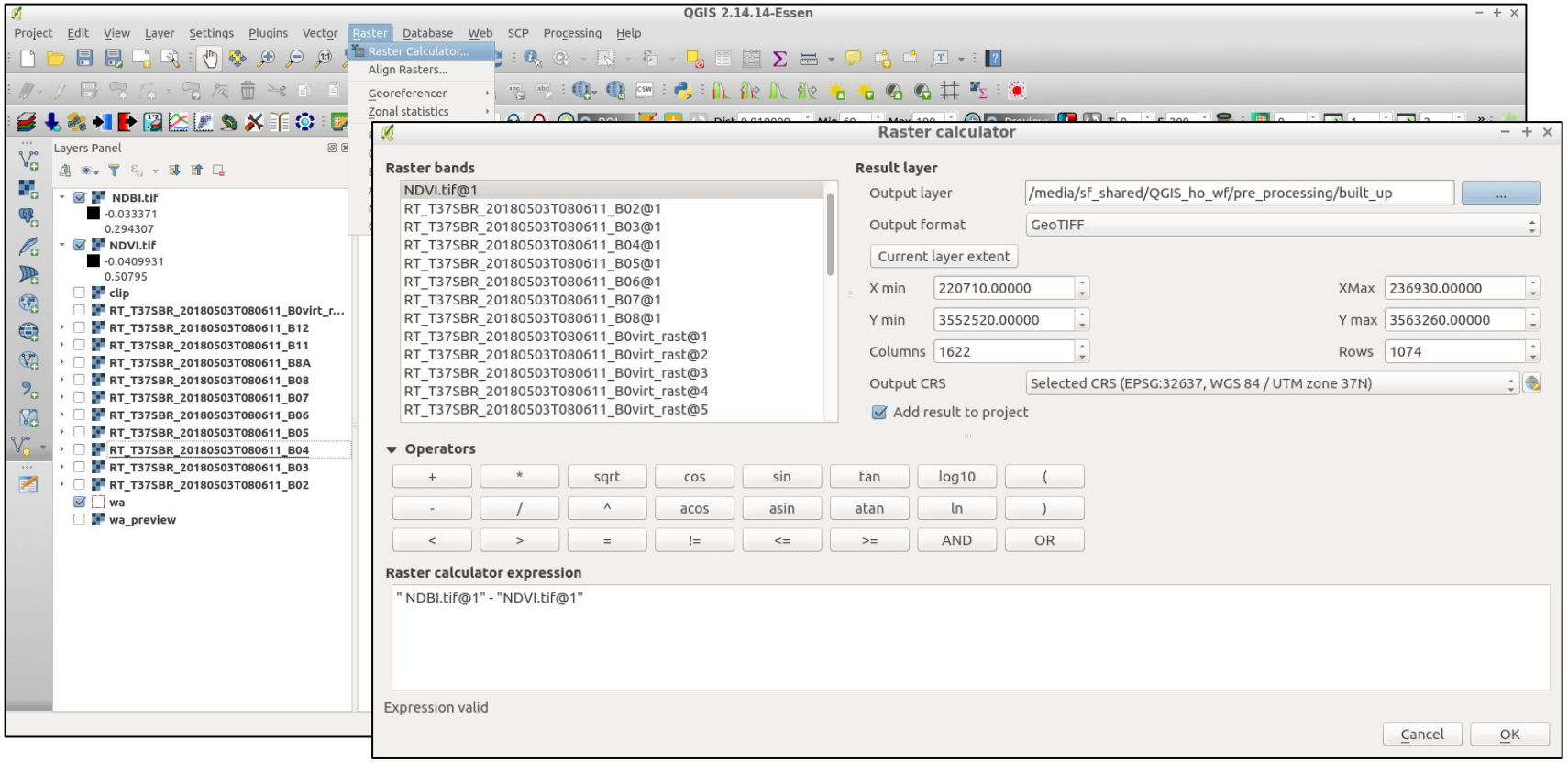
✓ The computed raster layers are saved in your local memory and added to your QGIS project



# Raster calculator: QGIS (core) raster calculator

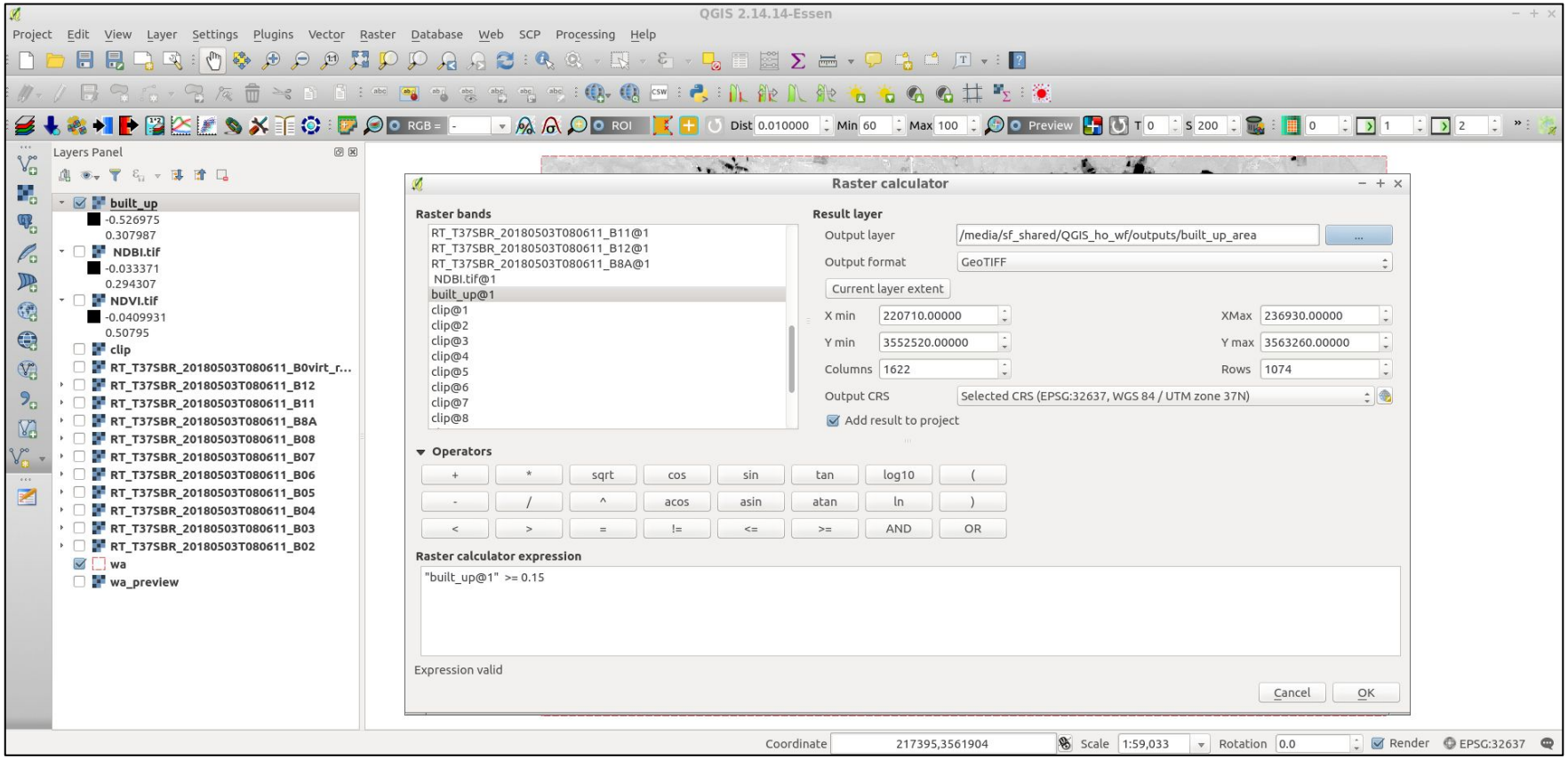
✓ A possible improvement of the automatic classification of built-up areas can be obtained by correcting the NDBI using the NDVI as **Built-up = NDBI - NDVI** (Masek et al. 2000)

✓ On the Bar Menu open ***Raster*** → ***Raster Calculator*** . Type the above equation and define the features of the output layer (*see the figure*)



# Raster calculator: QGIS (core) raster calculator

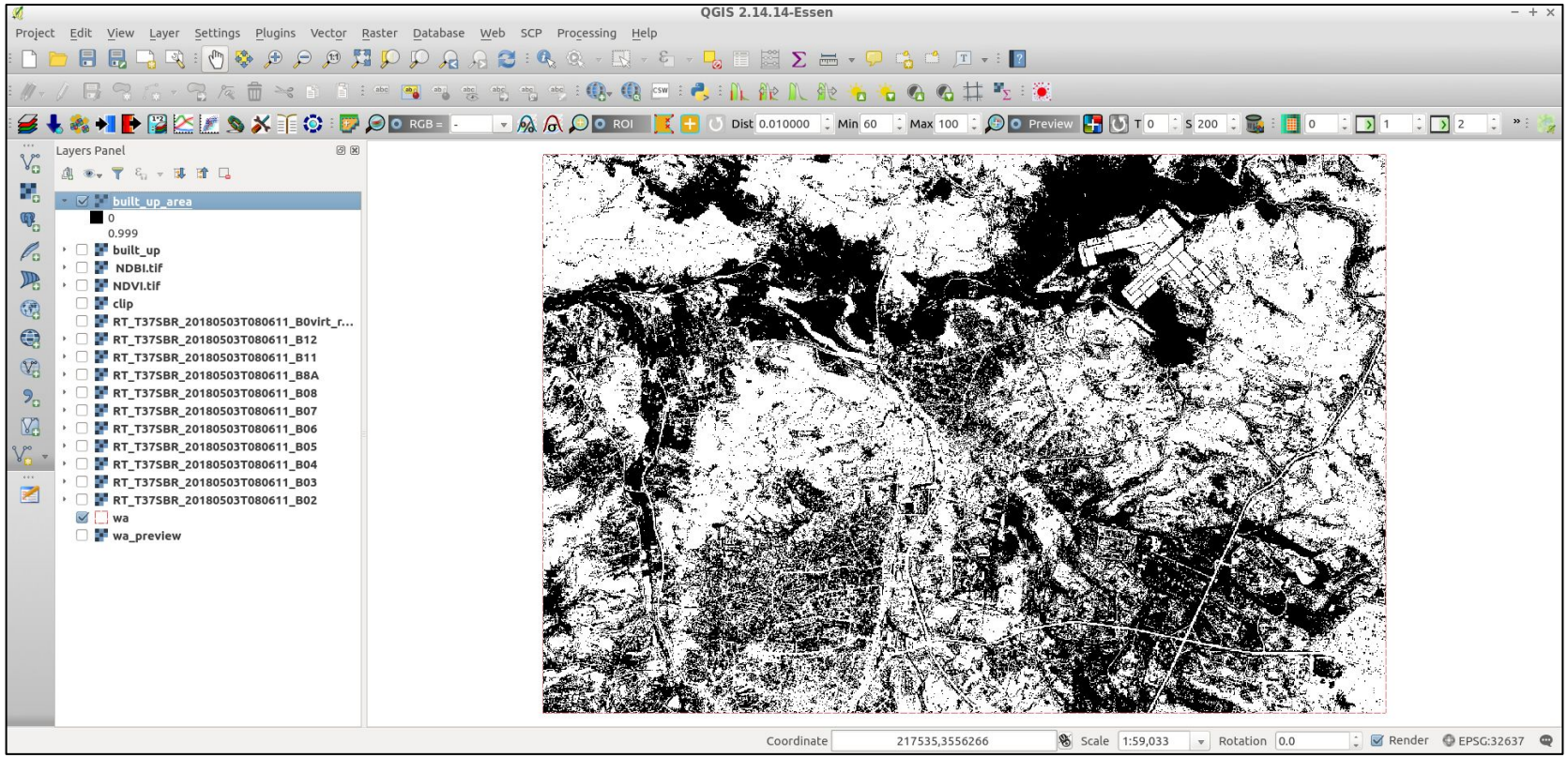
✓ In order to create a classification raster (built-up = 1 / non built-up = 0), we can create a Conditional Raster using the ***Raster Calculator*** by setting a threshold on the Built-up values (*see the figure*)



# Raster calculator: QGIS (core) raster calculator

✓ The classified raster layer is saved in your local memory and added to your QGIS project

✓ Visually compare the obtained classification with the reference natural color imagery (*clip.tif* or *wa_overview.tif*) and make your judgments



# Skills notebook

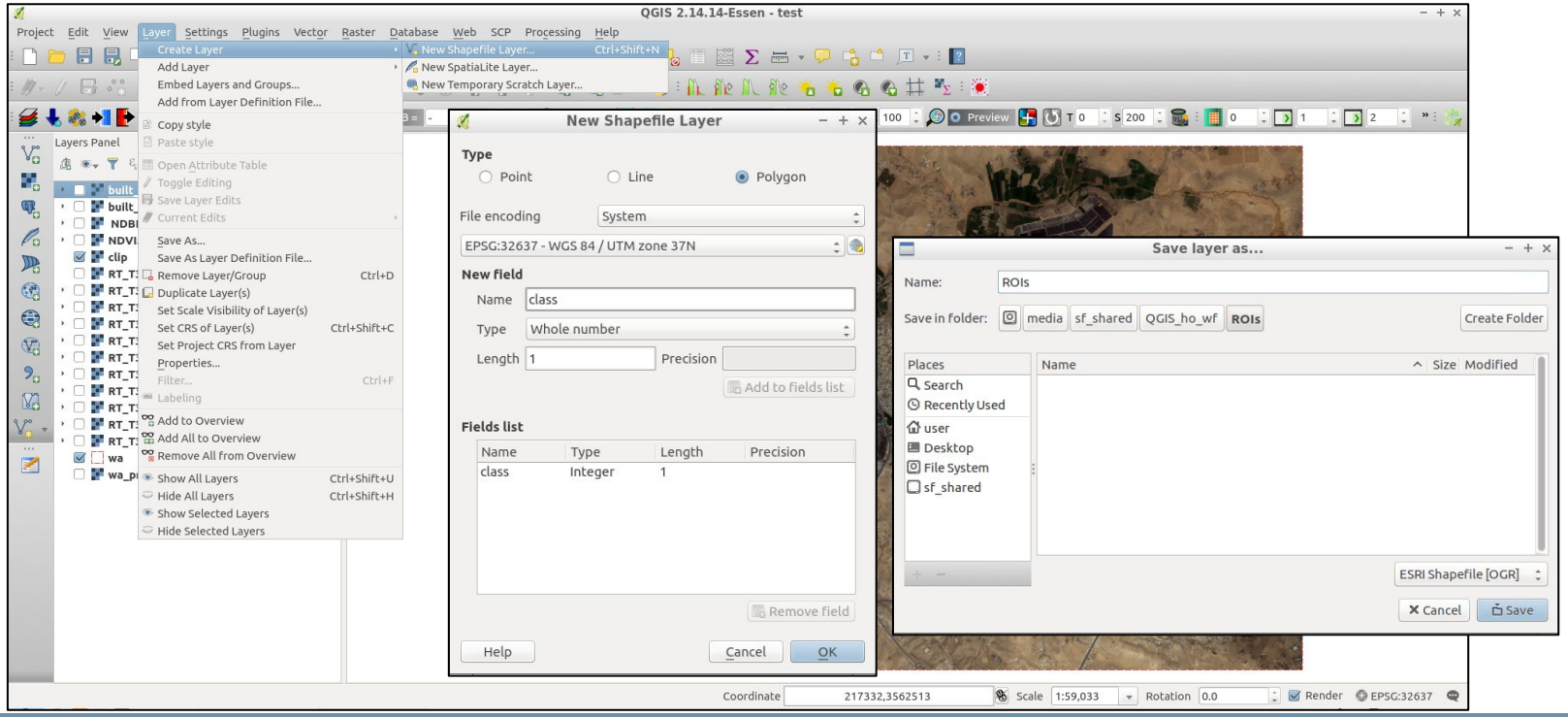
- [x] Activate basemaps from external providers for your QGIS project
- [x] Search and download satellite imagery data from QGIS
- [x] Full preprocessing of multispectral satellite imagery with QGIS using both Plugins and Processing algorithms
- [x] Manipulate raster bands to compute graphical indicators and conditional rasters for analysing remote sensing data

# Advanced vector layers editing

✓ Let's now try to perform a supervised classification for the preprocessed images, by following the previously attempted classification of built-up areas.

✓ First, we need to define training areas within our working area. These will be edited manually as a **multi-polygon shapefile** which will contain an **attribute** field describing the belonging of each polygon to the classes: **0 = non bulti-up, 1 = built-up**. (*Assign the same CRS of the multispectral clipped raster layer we create before!*)

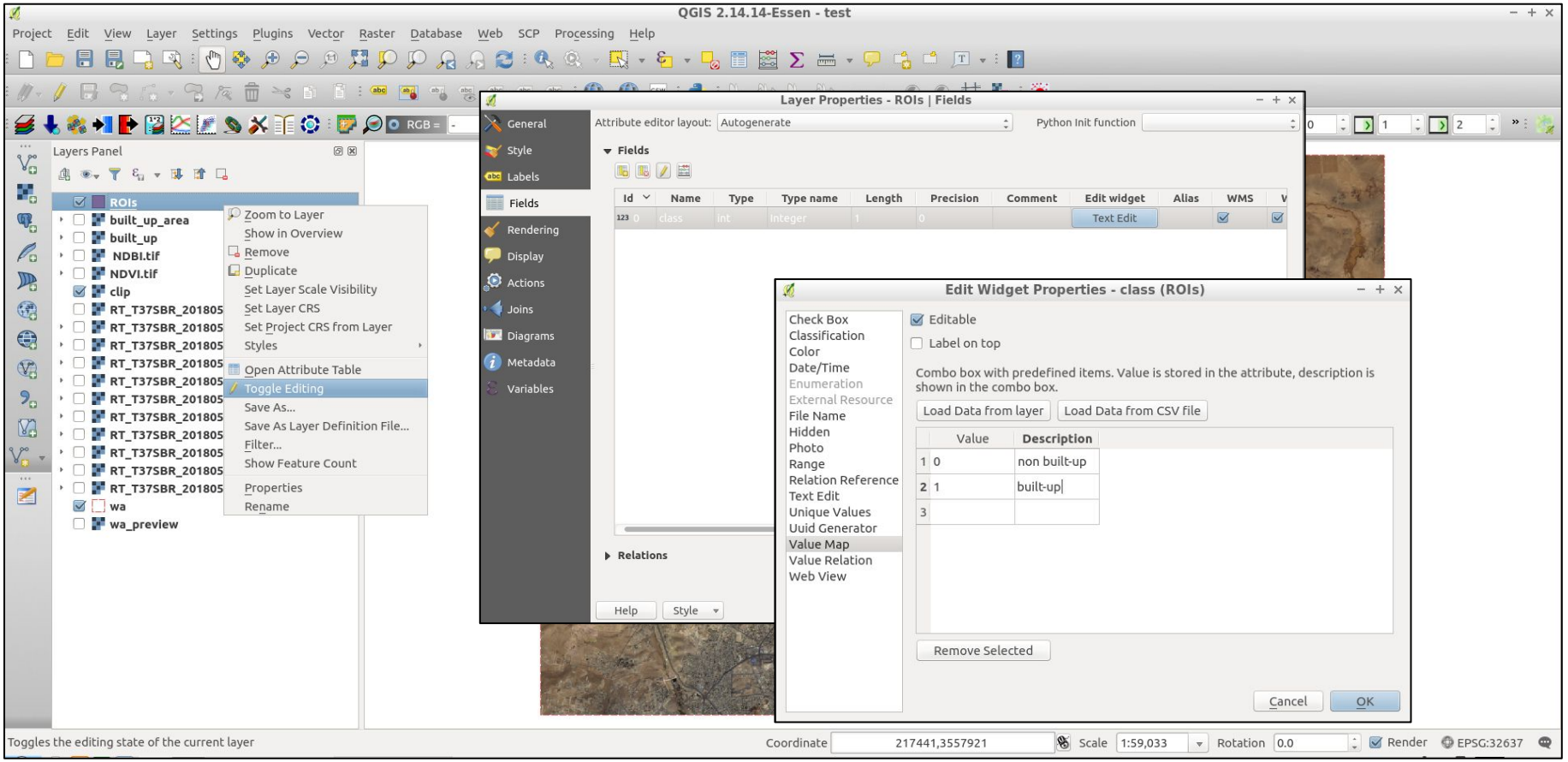
✓ On the Bar Menu select ***Layer*** → ***Create layer*** →***New shapefile layer***. Define first a type and a name for the new layer and second, specify its attributes (*see the figure*)



# Advanced vector layers editing

✓ Right click on the layer name and select ***Toggle Editing*** 

✓ Right click on the layer name and select ***Properties*** → ***Fields***. For the '*class*' attribute modify the ***Edit widget*** to ***Value Map***. Specify two classes of value: **0 = non bulti-up, 1 = built-up**, then press ***Ok***. The ***Value Map*** option helps to edit the attribute of any new geometry drawn in the new shapefile layer. This will assign labels to your values (0,1) to facilitate the editing task

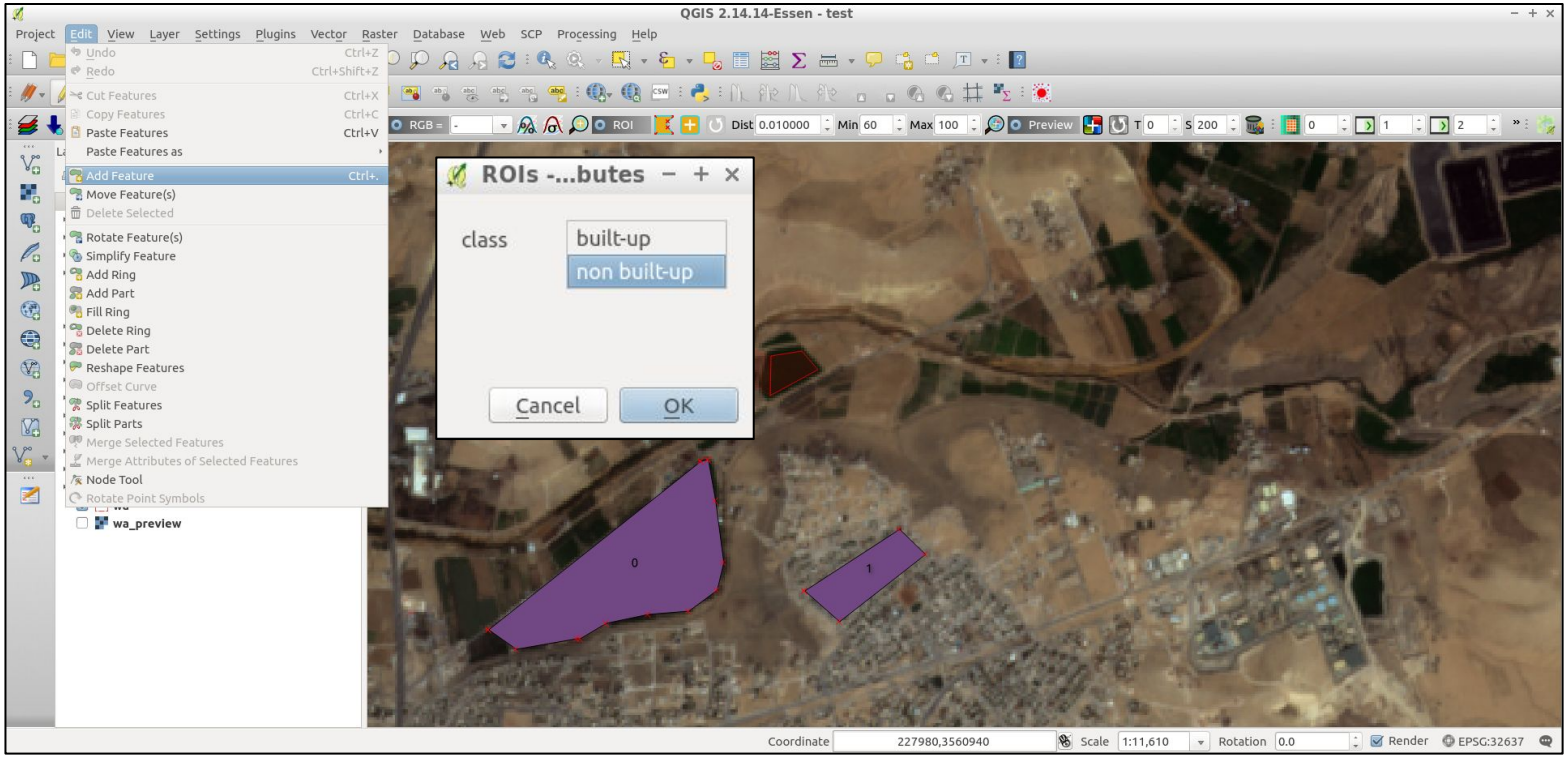


# Advanced vector layers editing

✓ Start to digitalize the training areas by selecting from the Bar Menu ***Edit*** → ***Add feature*** 

✓ Click on the Map panel to create the polygon vertices, Right-click to end the polygon drawing. Use a natural color imagery of the working area as reference. Once the drawing is done, define the type of class with the attribute ***Editing widget***

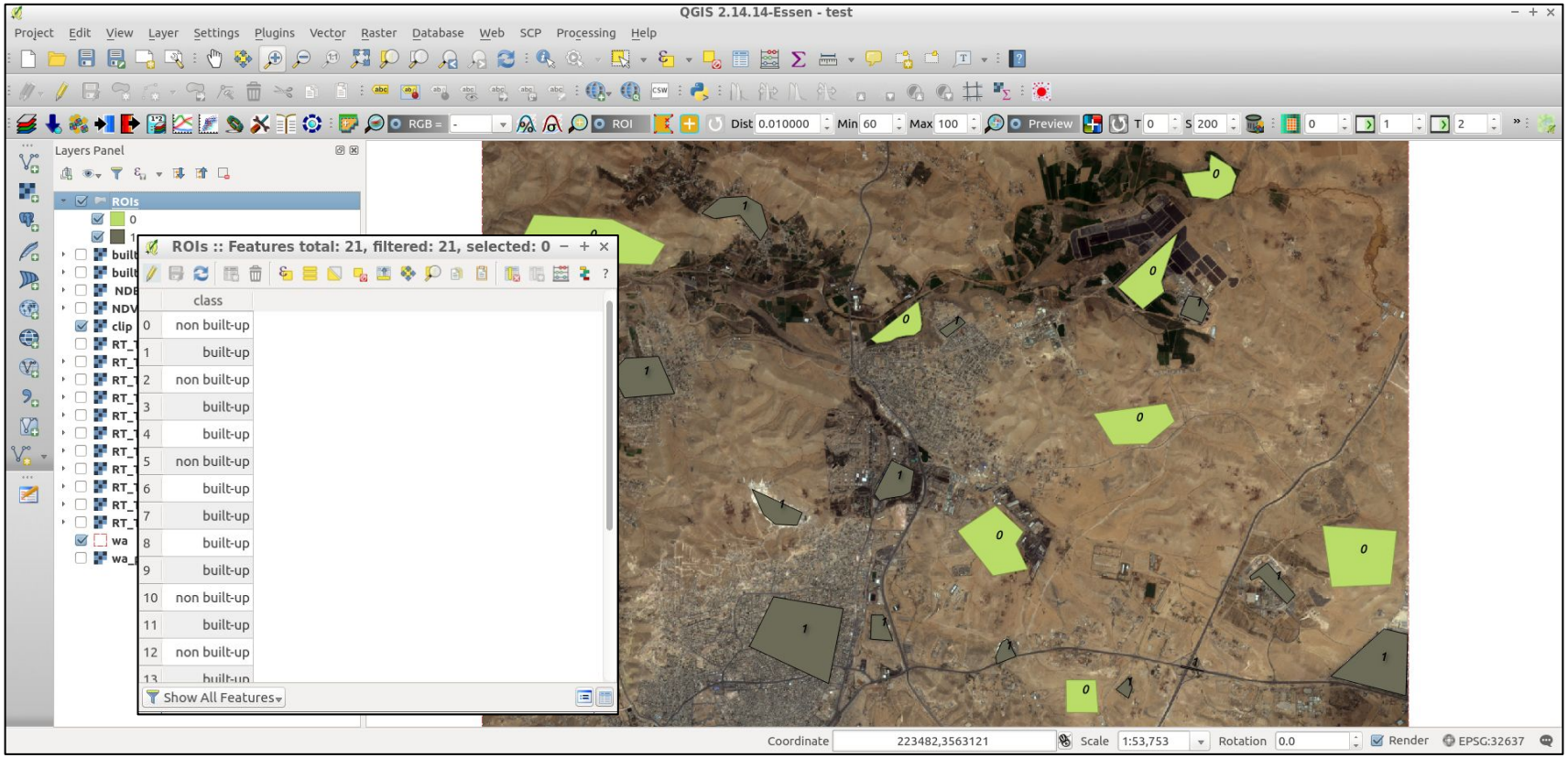
✓ Create a suitable amount of polygons (for this exercise ~ 15) trying to cover any different situation for built-up and non built-up areas (e.g. sand, crops, dense buildings, scattered buildings, roads, etc.) in the working area.



# Advanced vector layers editing

✓ To conclude the editing and save the changes press the ***Toggle Editing***

✓ Your new shapefile layer now contains the training areas for performing a supervised classification. The quality of this latter strongly depends on the quality of the selected (and mapped) training areas



# Skills notebook

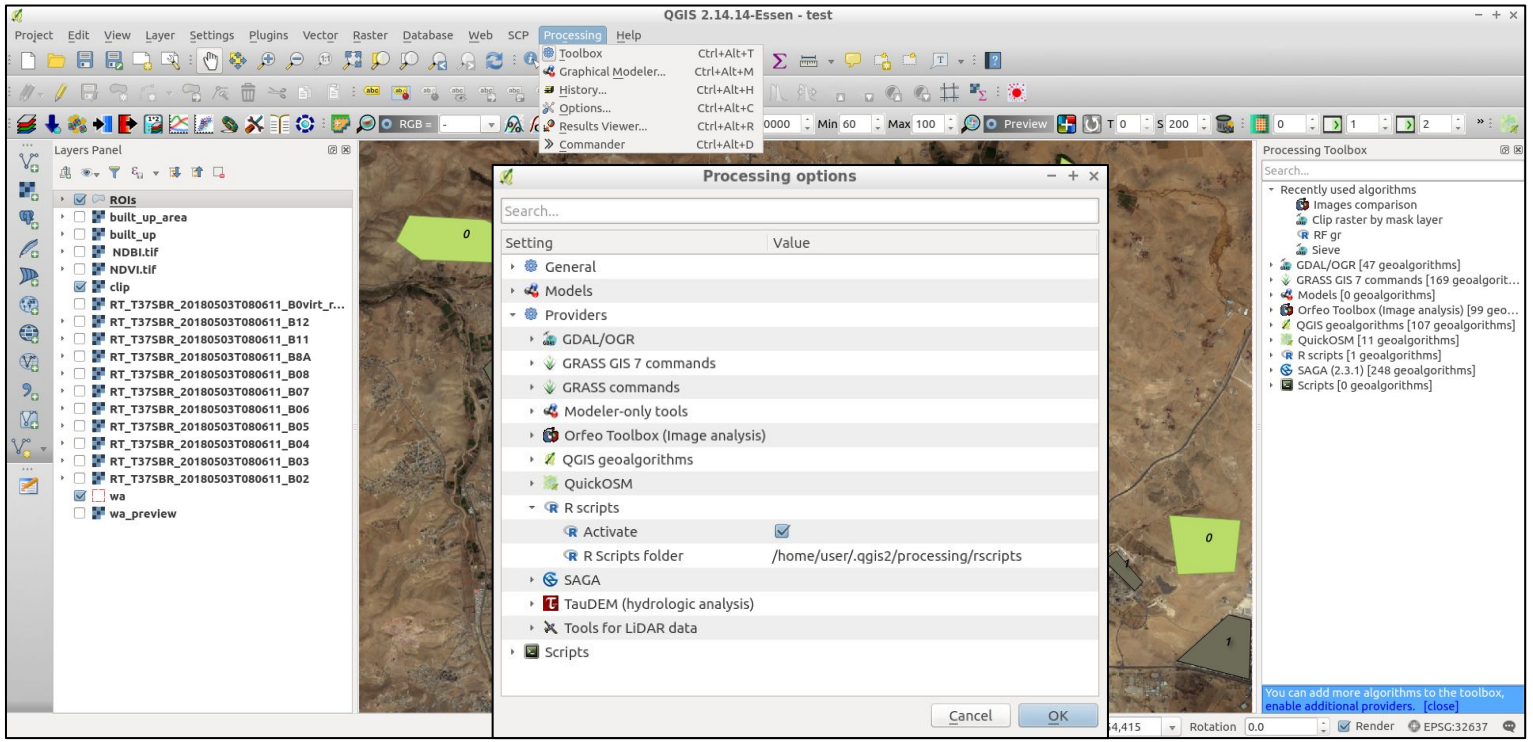
- [x] Activate basemaps from external providers for your QGIS project
- [x] Search and download satellite imagery data from QGIS
- [x] Full preprocessing of multispectral satellite imagery with QGIS using both Plugins and Processing algorithms
- [x] Manipulate raster bands to compute graphical indicators and conditional rasters for analysing remote sensing data
- [x] Edit vector layers in QGIS and speed-up the editing of attributes using the Value Map option

# Extending QGIS functionalities: Add a custom script to the Processing Toolbox

- ✓ QGIS does not provide always core functionalities to accomplish complex geoprocessing such as images classification. Nevertheless QGIS can be extended with processing tools both from external providers as well as programmed by the users. This is allowed by the ***Processing Toolbox***

- ✓ In this exercise, we will see how to import a custom R script enabling to perform supervised image classifications using the Random Forest algorithm

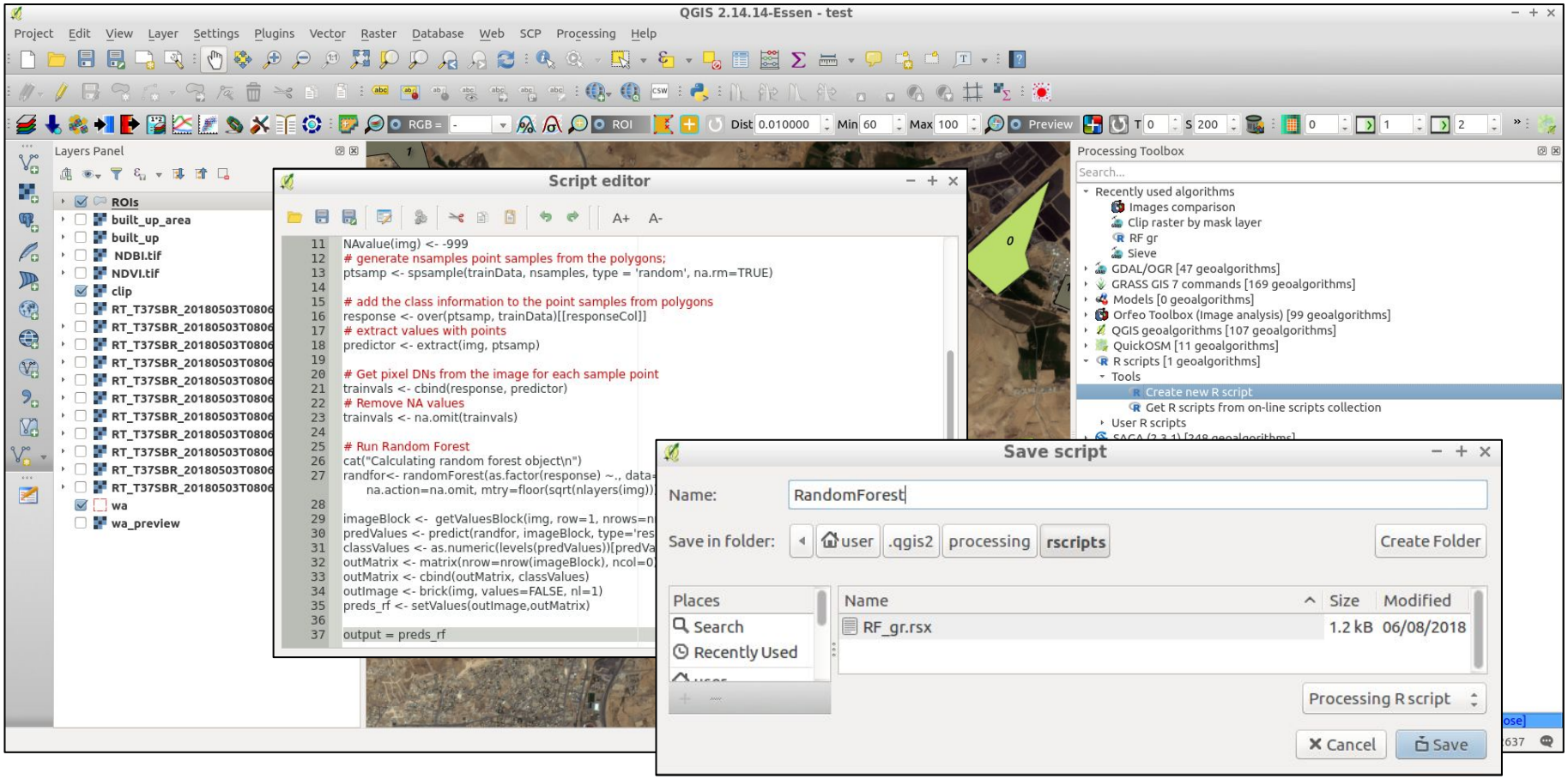
- ✓ On the Bar Menu select ***Processing*** → ***Options*** →***Providers*** and ***Activate*** the ***R scripts***. Then, activate the ***Toolbox***



# Extending QGIS functionalities: Add a custom script to the Processing Toolbox

✓ On the ***Processing Toolbox*** panel go on ***R scripts*** →***Create new R script***. Open text file 'RF_gr' you can find in the exercise data folder at: *'QGIS_ho_wf' -> 'Rscripts'*. Copy the text of the file in the ***Script editor*** and save it (*do not change the suggest path during the save operation!*)

✓ The script will appear under ***Processing Toolbox*** → ***R scripts*** →***User R scripts***

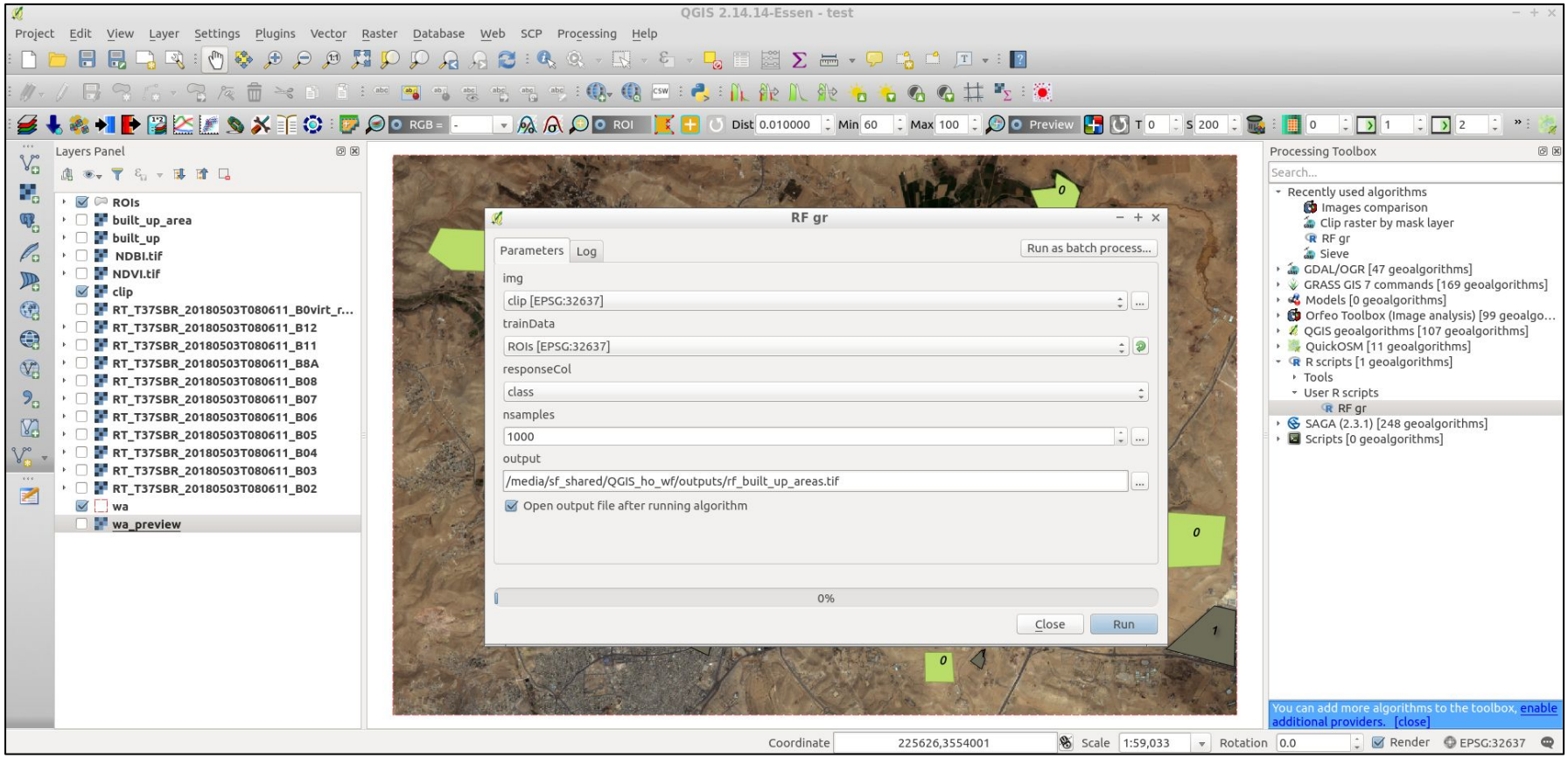


# Skills notebook

- [x] Activate basemaps from external providers for your QGIS project
- [x] Search and download satellite imagery data from QGIS
- [x] Full preprocessing of multispectral satellite imagery with QGIS using both Plugins and Processing algorithms
- [x] Manipulate raster bands to compute graphical indicators and conditional rasters for analysing remote sensing data
- [x] Edit vector layers in QGIS and speed-up the editing of attributes using the Value Map option
- [x] Add a custom script into QGIS

# Extending QGIS functionalities: Perform a supervised image classification for built-up areas

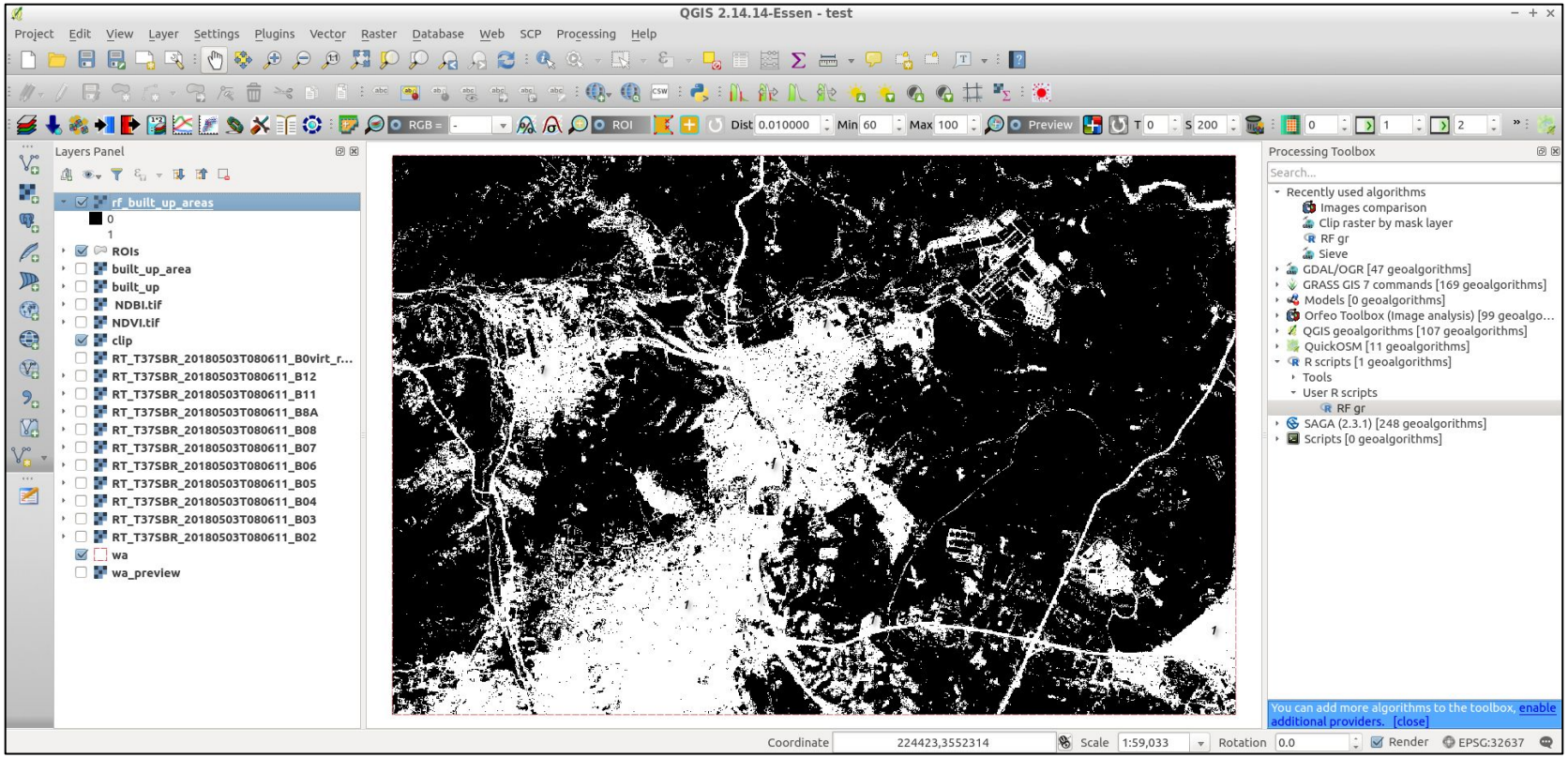
✓ Click on the script name. Specify the image to be classified (*use the multispectral raster layer from the Sentinel-2 imagery clipped on the working area*), the shapefile containing the training areas, the attribute of the shapefile containing the classes, and a name for the output classified raster layer. Then press ***Run***



# Extending QGIS functionalities: Perform a supervised image classification for built-up areas

✓ The classified raster layer is saved in your local memory and added to your QGIS project

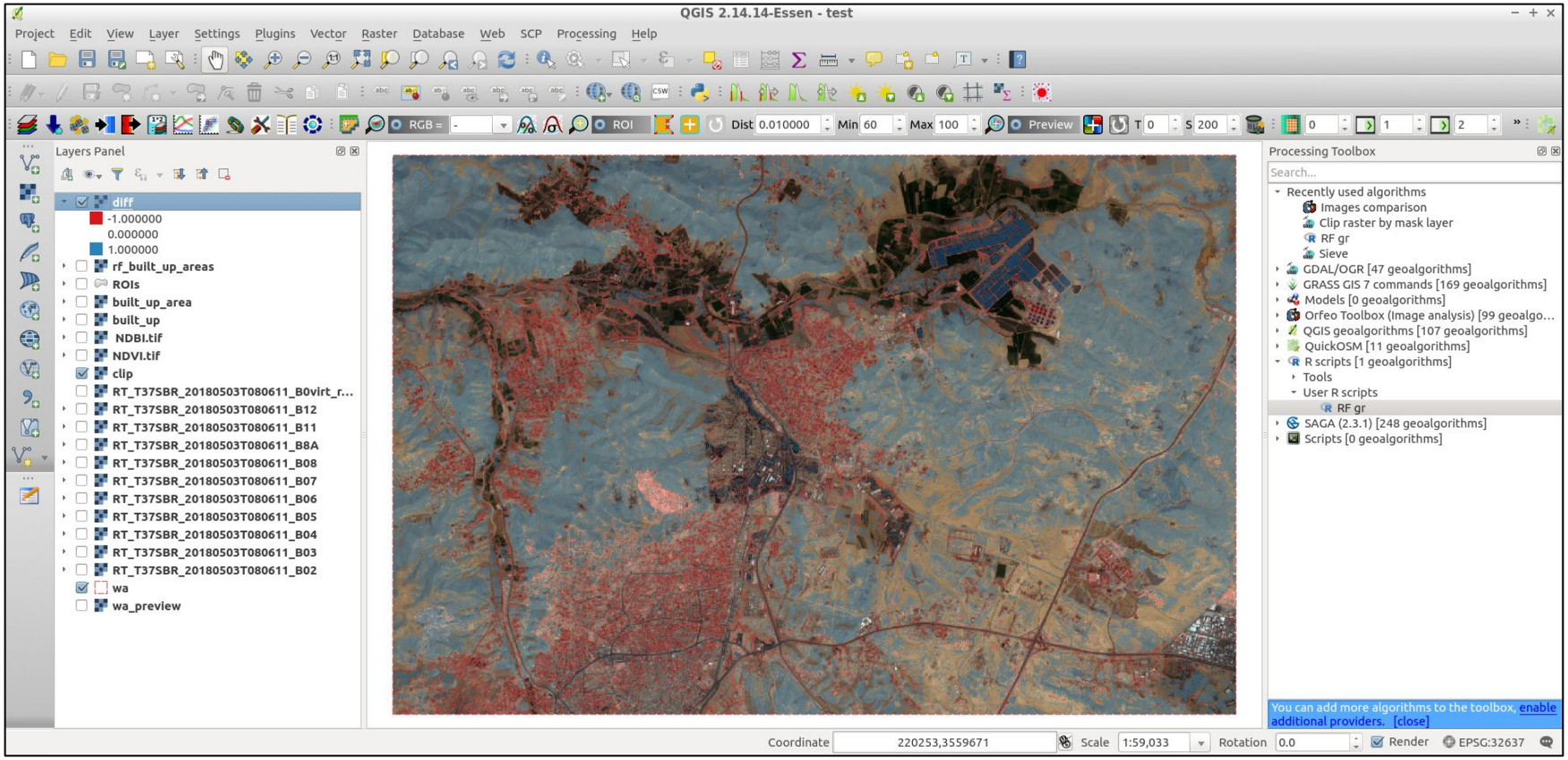
✓ Visually compare the obtained classification with the reference natural color imagery (*clip.tif* or *wa_overview.tif*) and the classified map obtained from the NDBI computation. Make your judgments



# Extending QGIS functionalities: Perform a supervised image classification for built-up areas

✓ To better outline the differences between the two classified layers, use the ***Raster Calculator*** to compute the map of the differences (**classified_layer1 - classified layer 2**)

✓ We obtain a raster having 3 values (-1, 0, 1) depicting the pixel wise agreement of the two classifications



# Skills notebook

- [x] Activate basemaps from external providers for your QGIS project
- [x] Search and download satellite imagery data from QGIS
- [x] Full preprocessing of multispectral satellite imagery with QGIS using both Plugins and Processing algorithms
- [x] Manipulate raster bands to compute graphical indicators and conditional rasters for analysing remote sensing data
- [x] Edit vector layers in QGIS and speed-up the editing of attributes using the Value Map option
- [x] Add a custom script into QGIS
- [x] Perform a supervised classification with QGIS using custom geoprocessing scripts

# Hands-on session: QGIS

# … Questions?

Daniele Oxoli

*PhD Candidate & Research Fellow*
*Politecnico di Milano - GEOlab*
*P.zza Leonardo da Vinci 32,*
*20133 Milano (IT)*