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SUNRAISE: Sustainable Natural Resource Use in Arctic and High Mountainous Areas

Report on:

Document for Summer/Winter School or Training

Hands-on course on *Basics of Satellite Data Processing*

Partner number: P12

Jawaharlal Nehru University, New Delhi

India

Hands-on course
on
Basics of Satellite Data Processing

Note: *A Document for Summer/Winter School or Training under the SUNRAISE Project*

SUNRAISE

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Preface

These are exciting times for the satellite remote sensing data processing and spatial data analysis. Gone are the days when access and availability of satellite data were limited. Similarly access to the platforms, software and packages were limited. Today, in the world of open and free access to data and software, using satellite data inputs are simply limited to browsing a web page. These web pages provide gateway to wider range of satellite remote sensing data.

Having access to such database and platform is important for the students and researchers in low income and developing countries. These are also important for extraction of information for the rugged and inaccessible terrains like mountains. Researcher and Policy makers wish to quickly process satellite remote sensing data to extract information almost in real-time.

One of the most challenging issues is capacity to access and process such datasets. This manual provides a *Hands-on course on Basics of Satellite Data Processing* for such group. The course document is prepared keeping the fundamental image processing techniques and satellite data processing in view so that anyone with a basic understanding of computers and interest in this field should be able to quickly learn through this document. Within the scope SUNRAISE Project, the document serves as an open course material so as to enable students, researchers, professionals and in-service people to learn and apply these tools to extract information from satellite remote sensing data.

Acknowledgement

This manual provides a *Hands-on course on Basics of Satellite Data Processing* is an outcome of the course development for the course material for SUNRAISE Project.

We thank the team members of the SUNRAISE Project who have worked at the Jawaharlal Nehru University for helping in developing this manual.

This manual is used by the students of MA Disaster Studies and doctoral researchers at the Special Centre for Disaster Research (SCDR), Jawaharlal Nehru University, New Delhi. Many thanks to them for providing feedback to bring it to current shape.

We also wish to use this manual for training students and researchers with other partners of the SUNRAISE Project in India. We are thankful to them for showing interest in this.

While preparing it, wide range of resources from internet were used. We have taken care while giving the weblinks. Still if anything is missing, that is purely unintentional.

We wish this document to be used for training and capacity building programs purely for non-commercial purpose. We will be happy to provide any further details and updates as and when carried out.

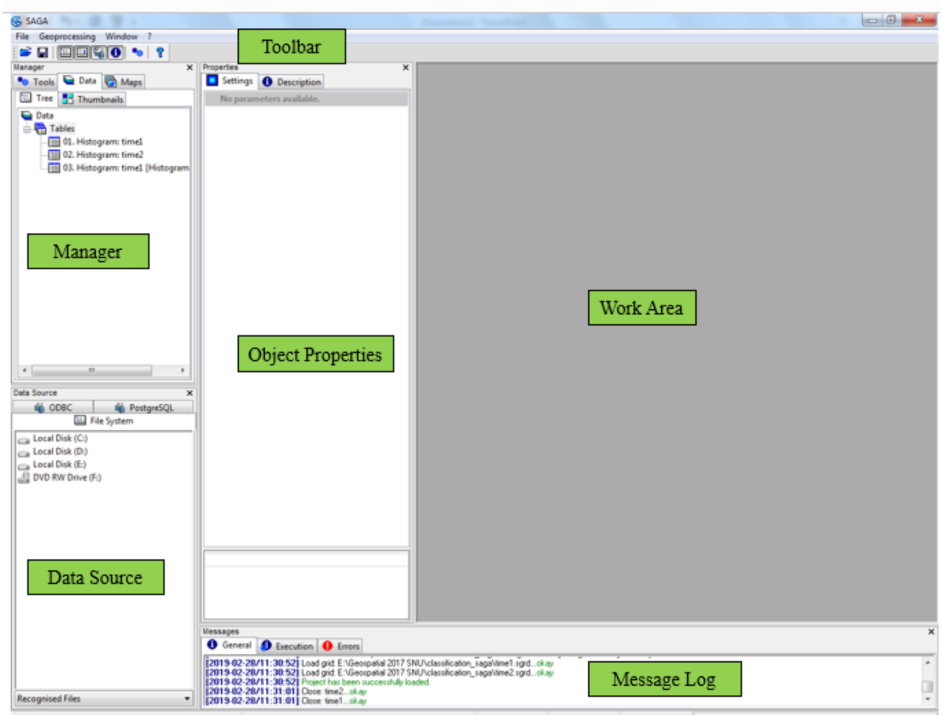
INTRODUCTION TO SAGA

Introduction

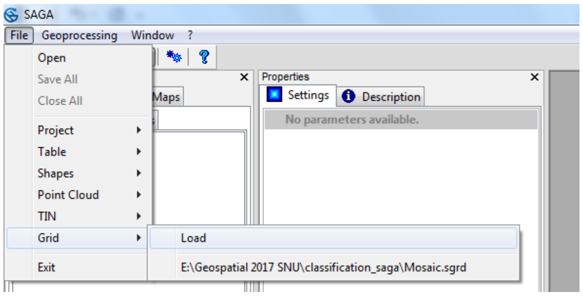
SAGA (System for Automated Geoscientific Analyses) is an open-source digital image processing GIS program capable of processing images in different formats. It uses the well-established GDAL/OGR library to import and export images to and from its native format, SAGA Grid (*.sgrd).

In this tutorial, we will use imagery from the Landsat 8 sensor. This image is a composite of 6 bands i.e. Band 1 (Blue), Band 2 (Green), Band 3 (Red), Band 4 (Near IR) and Band 5 and 6 (Shortwave IR). These are renamed bands and do not represent their actual band number in the raw satellite image. The image covers the city of Dehradun and its surround areas. In this tutorial we will learn how to handle, view and save raster data.

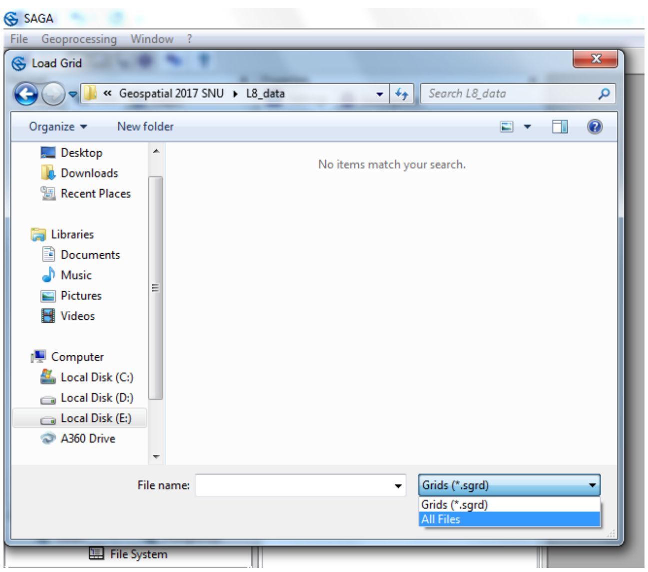
SAGA is available as a stand-alone program which means it does not have an installation procedure. To start SAGA, navigate to the SAGA folder, look for the 'saga_gui.exe' icon and double-click on it. The SAGA window will open. The different components of the window are given below.

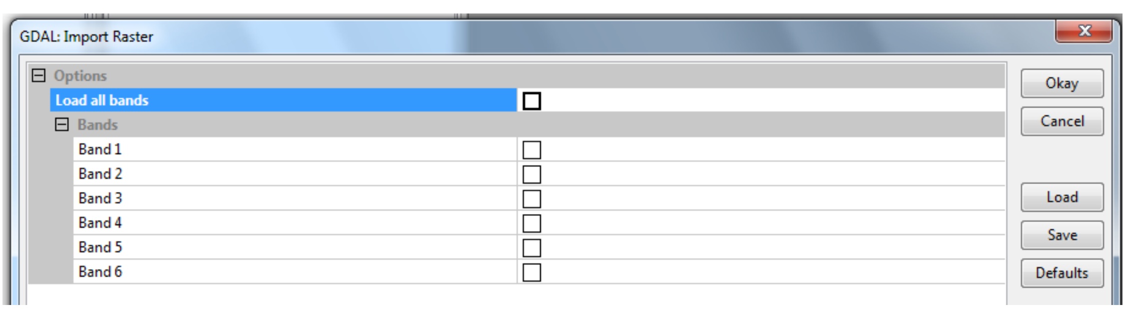


We will start by opening an image in the program. To open the image, click on the 'Load' button in the toolbar, or open it via the menu (File → Grid → Load)

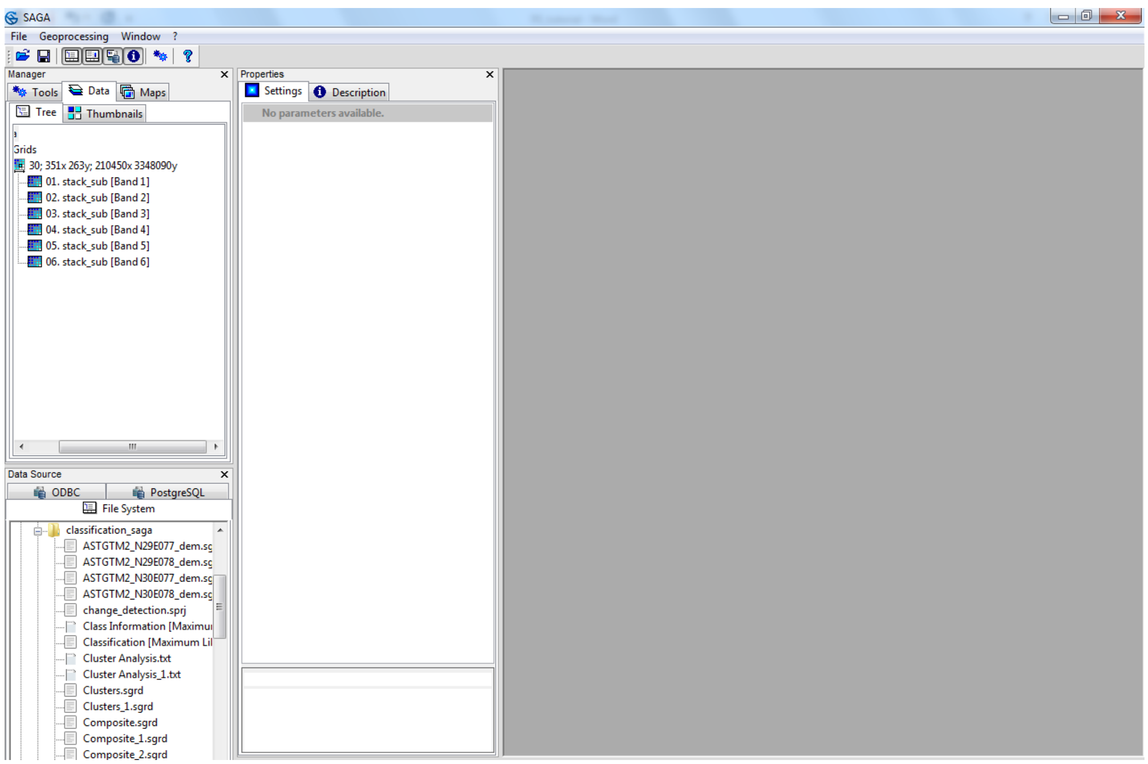


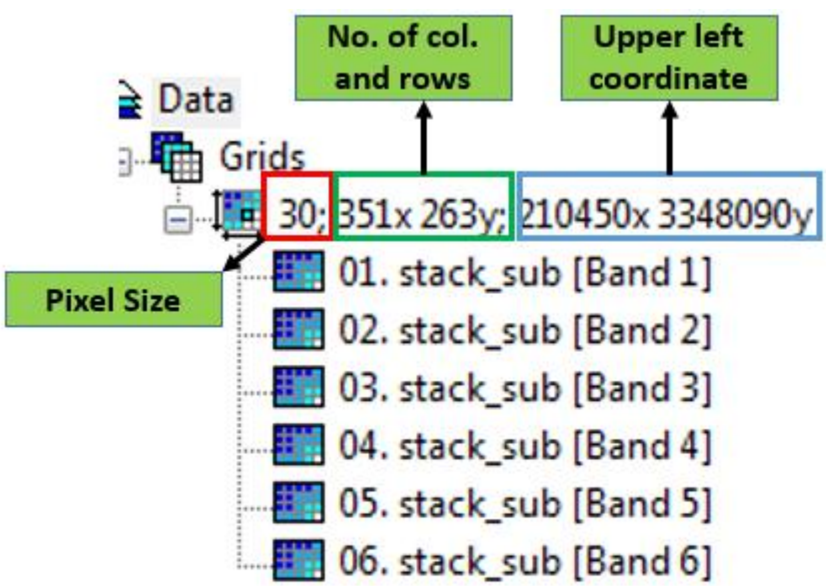
This will open a window from where we must navigate to our image folder. The images may not be immediately visible. At the bottom right of the window beside File name, there will be a drop down menu. Change the selection to 'Recognized Files'. Now, select 'stack_sub' and click 'Open'. This imports the images into temporary *.sgrd images.





To see the list of these images, click on the Data tab under the Manager section. This tab displays all the data that has been loaded into SAGA. In SAGA, raster data is stored in a grid system. Each grid system contains images having the same pixel size, extent, and location. Accordingly, the default name of the grid indicates the pixel size, number of rows and columns, and the coordinates of the upper left most pixel.



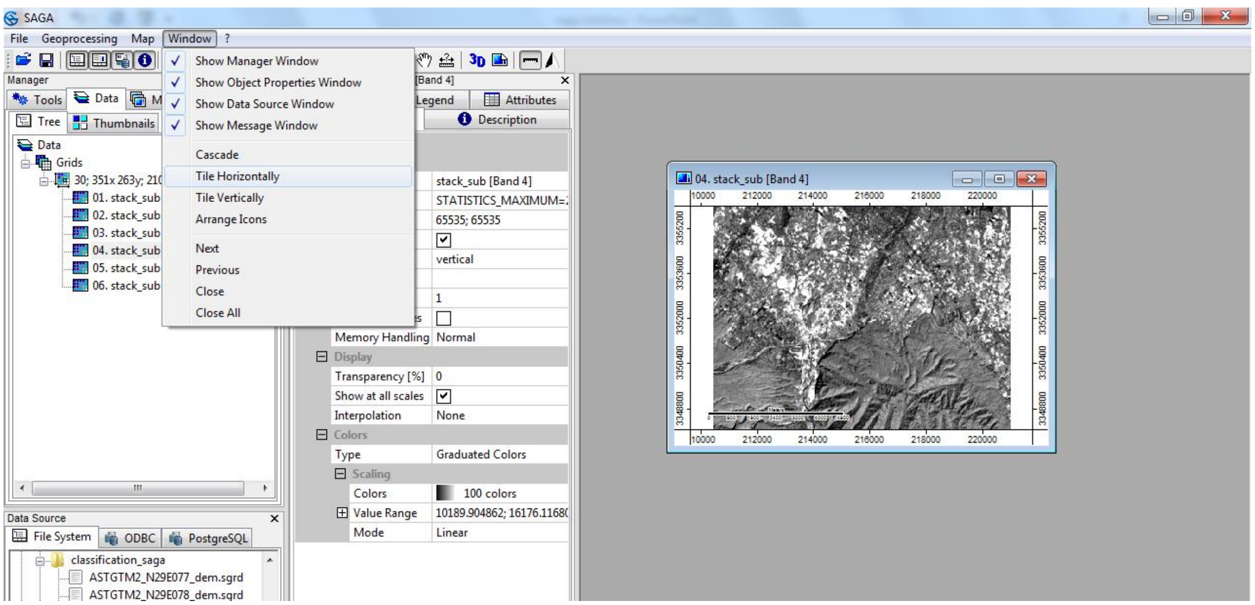


In this case our image grid has:

a) a pixel size of 30 m.
b) 351 rows and 263 columns
c) the coordinates of upper left pixel are (210450 x, 3348090 y)

If you wish to extend the size of the any window, place your mouse over the edge of the window. When you get a double headed arrow, click and drag to the required extent

To view an image, double-click on respective grid (for example: 'Band_4'). This will open the image in a window in the work area section.



Note: If the image is not loaded in greyscale as shown below, you can set the greyscale color ramp by using: Settings Tab →Colors→Type: Graduated Colors→Scaling→Click on color ramp to browse→Presets→Select→greyscale→OK→Click apply on Apply under Settings.

To the right/left of the map window is the 'Object Properties' section, in which information about the image is displayed. The different tabs of this section are described below:

a) Settings: Options related to the display of the data are found here.

b) Description: Description of the projection, geometry, extent, values and size of the data selected.

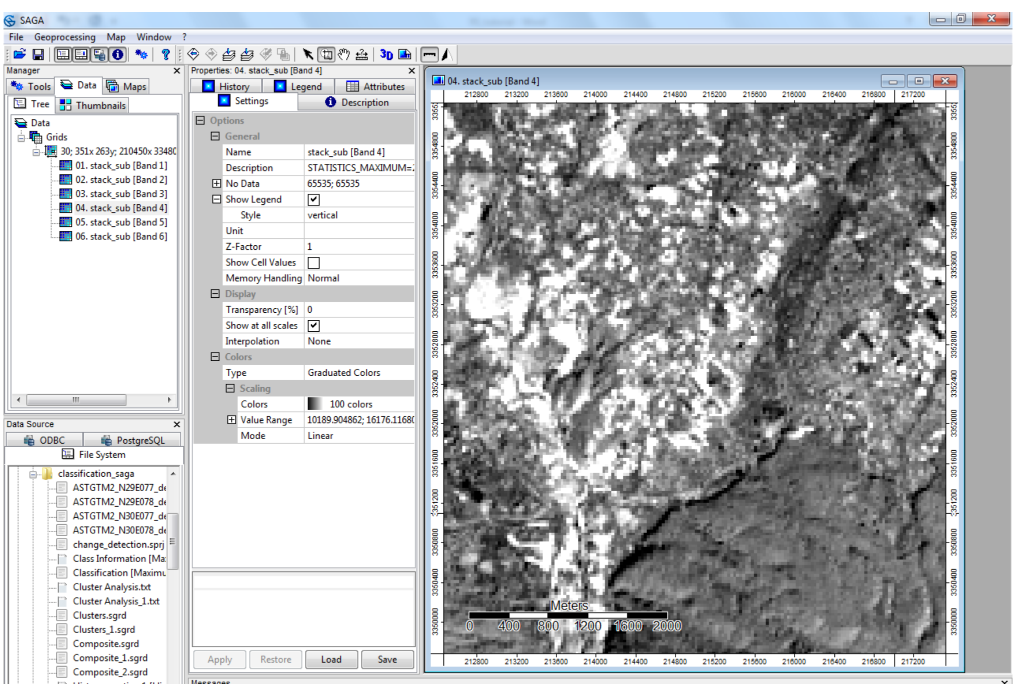
c) Legend: Displays the legend style of the data

d) History: Maintains a log of all the operations and changes carried out on this layer.

e) Attributes: This lists out the attributes of the selected data layer.

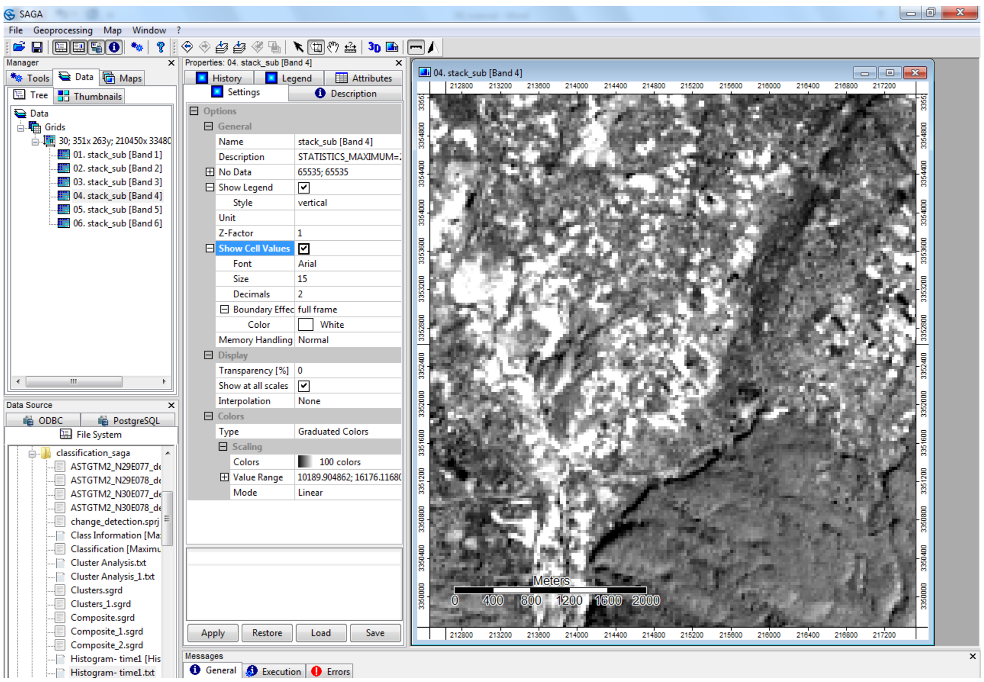
You might notice that on opening the image, another toolbar appears. This is 'Map' toolbar, and it contains some basic tools used in layer navigation and display.

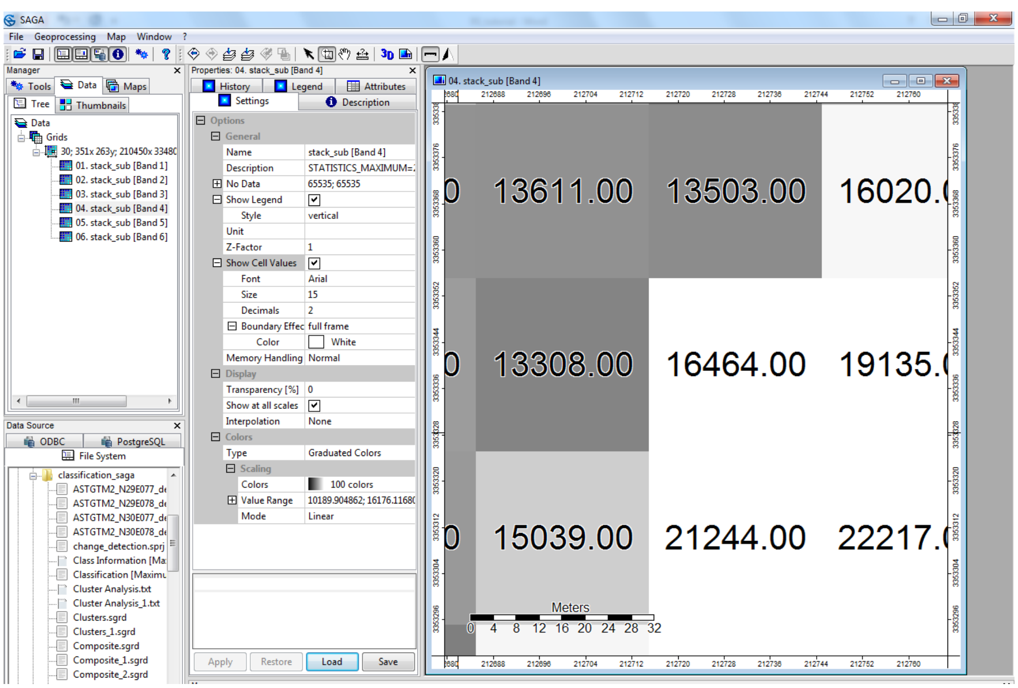
Click on the 'Zoom' button and then click and drag on the map to zoom in to a particular area (Alternately, we may use the mouse scroll wheel to zoom in and out). Zoom to the pixel level where every pixel can be easily distinguished from its neighbor.



In the Object Properties section, under 'Settings' tab there will be a field titled 'Show Cell Values'. Click on the check box next to it, and click on the 'Apply' button below.

You will see that the pixels in the image are labeled with their Digital Number values, the higher values being lighter and the lower values being darker.



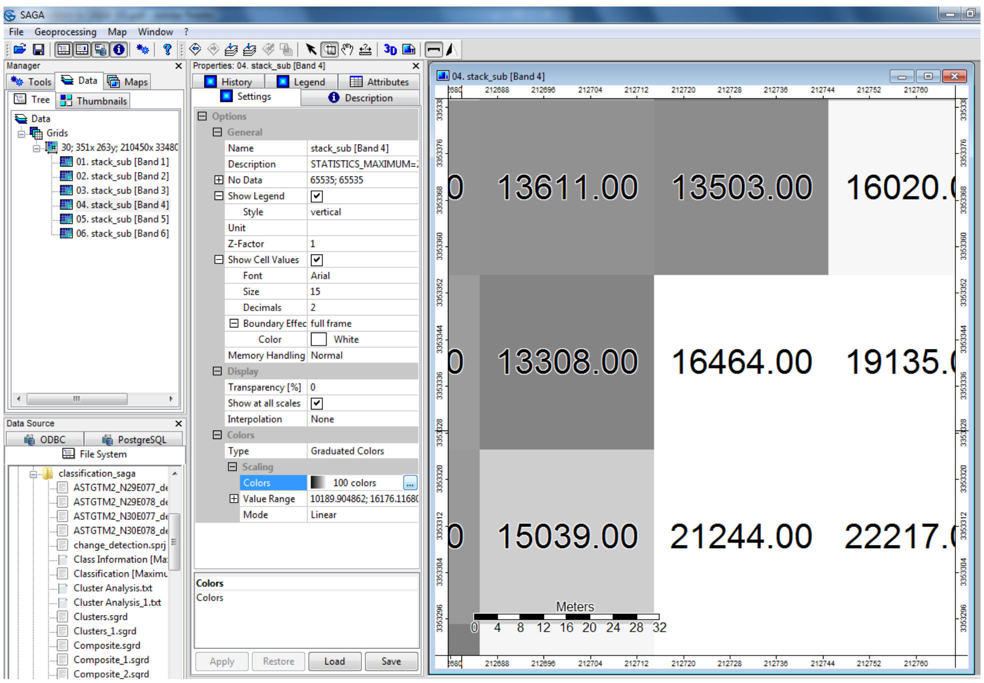


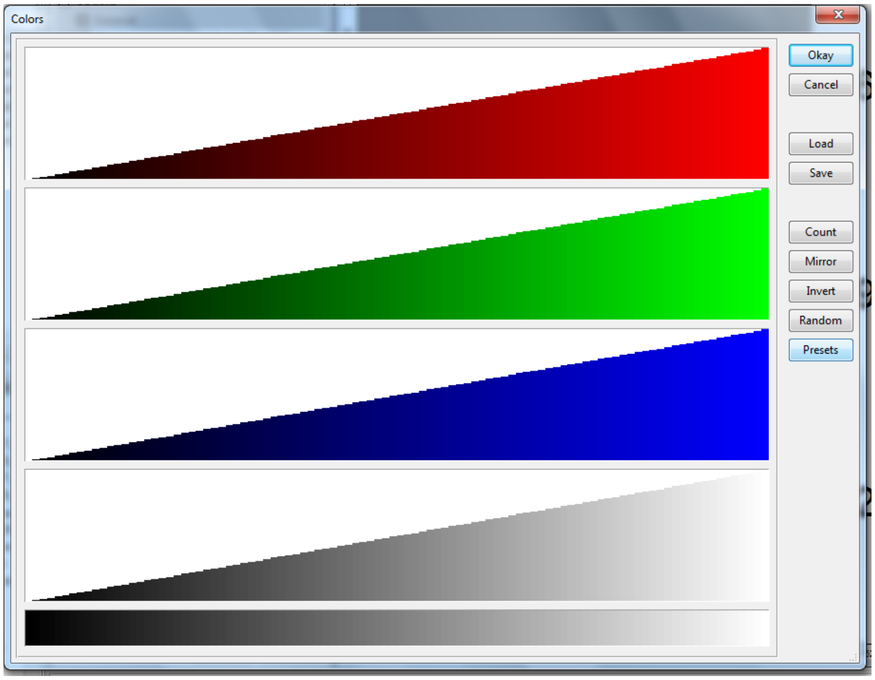
To move around the map, click on the 'Pan'  button and then click and drag the map.

The current colour ramp of the layers is ‘greyscale’. We may assign a different colour ramp by clicking on the 'Settings' 

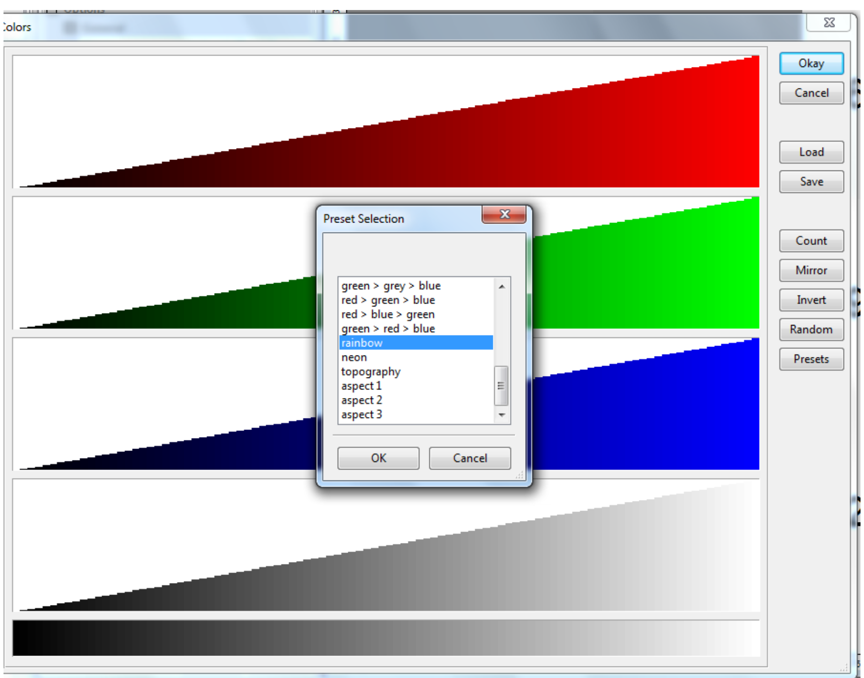
tab. Under the heading 'Graduated Color' is the entry 'Colors'. Next to this is the current colour ramp which looks like this 

. Select it and then click on the  button which appears on its right.

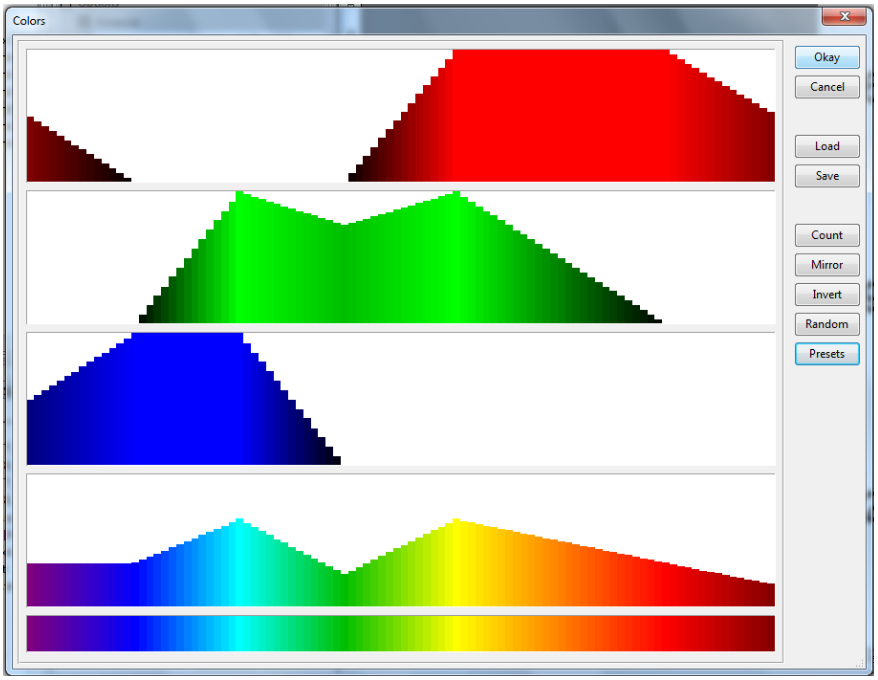




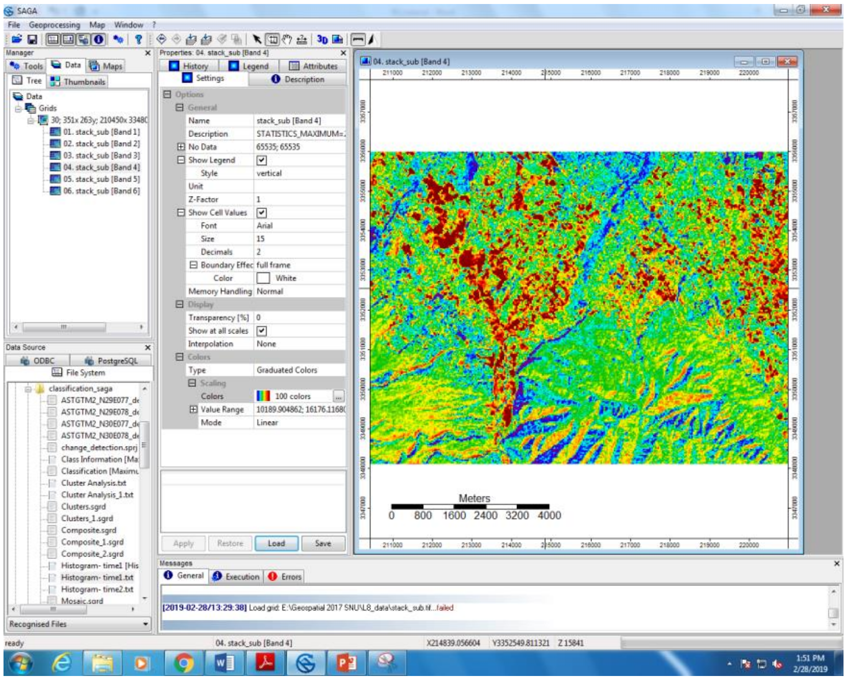
A Colors window appears, having 3 primary colour ramps which we can use to create our ramp. For now we will use a preset colour ramp. Click on 'Presets' and select 'Rainbow' from the Preset Selection List and click ‘OK’. Click 'Okay'. The settings of the layer will now look like this:



A Colors window appears, having 3 primary colour ramps which we can use to create our ramp. However, for now we will use a preset colour ramp. Click on 'Presets' and select 'Rainbow' from the Preset Selection List and click ‘OK’. Click 'Okay'. The settings of the layer will now look like this:



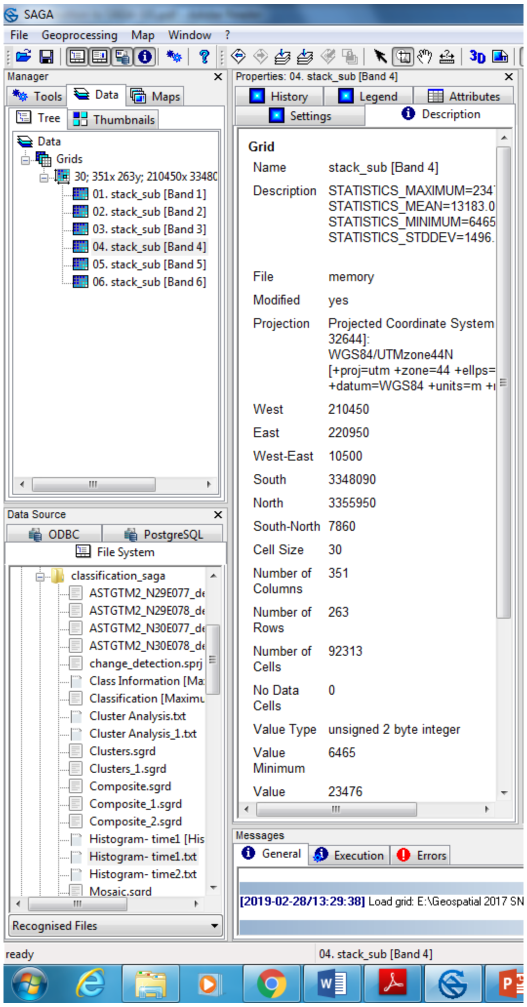
Click on the 'Apply' button located just above the 'Settings' tab. The image will now have the values colored according to the rainbow sequence, with blue for the lowest and red for the highest values.



Click on the 'Description' tab to view more information about the layer.

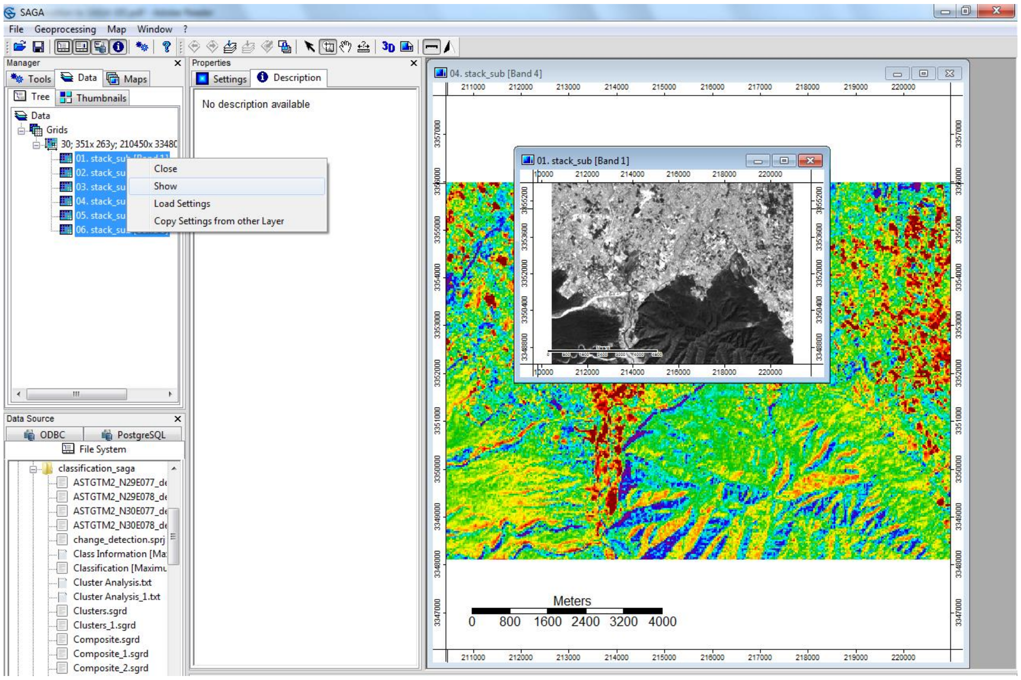
Under 'Projection' is given the projection parameters. Our image uses the WGS 84 Geographic Coordinate System. The identification code is EPSG 4326.

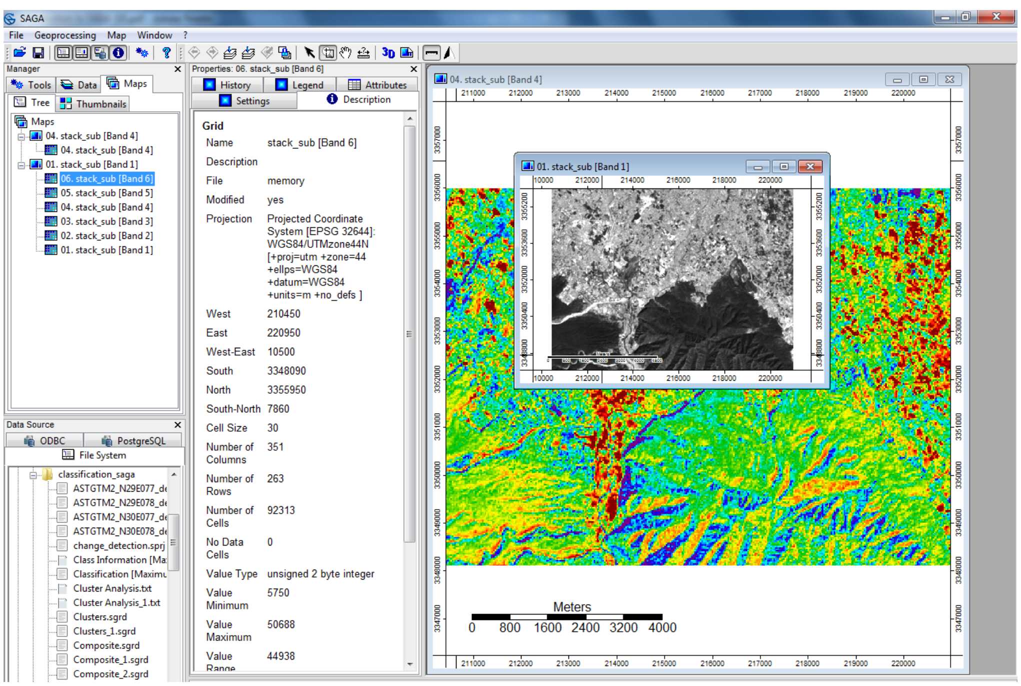
Below this is the East-West extent of the image. The width of the image is given below that. We can check this using the tools given in the Map Toolbar.



Click on the 'Zoom to Full Extent' button of the toolbar to view the entire image again. Now click on the 'Measure Distance' tool. The mouse cursor will change to a '+' sign. Click the left edge of the image and then click the right edge of the image.

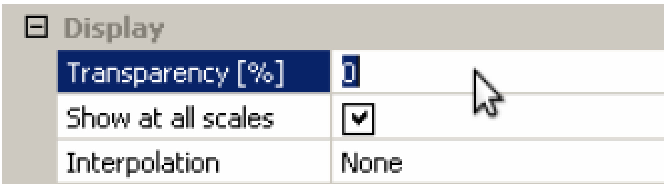
We will now add all the images to a map window, select all the images in the list by hold down the CTRL key and click on each of the images (Alternately, you can click on the first image, press SHIFT and then click on the last image). Right-click on them and click 'Show'. A window will pop up asking you which map you wish to add the layers to. Select 'New' and click on 'OK'.





The Layers are stacked on top of each other, and therefore are only visible one at a time. To view a layer below the topmost one, right-click on it and click 'Show Layer'. The layer will become invisible, allowing us to see the layer below it. (We can also do this by just double-clicking on the layer). The invisible layers will be marked with a bracket like this

Another way to view a lower layer would be to right-click on it and select 'Move to Top' from the dropdown menu. The layer transparency can also be changed by clicking on the 'Settings' tab on the right and then clicking on the space next to 'Transparency'. Type in the required transparency (Set it to 100 to make the layer invisible) then press 'Tab' in Keyboard. Click on 'Apply'.



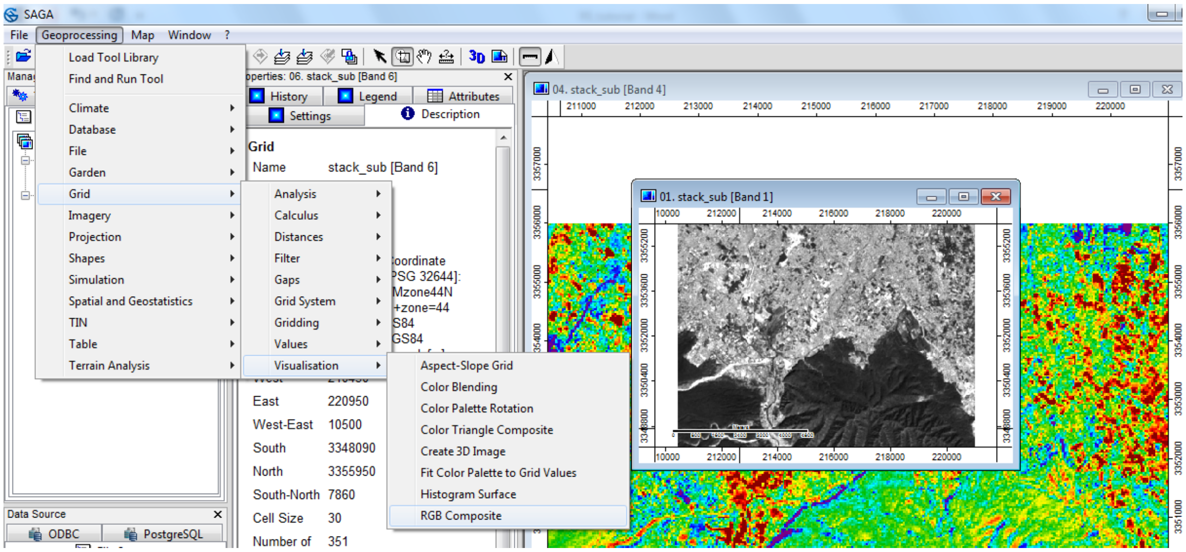
You may find that apart from the basic shapes, interpreting the image and the type of land cover is not possible by viewing it one band at a time. For this, we will need to view the image as a 'true color composite' or 'false color composite'.

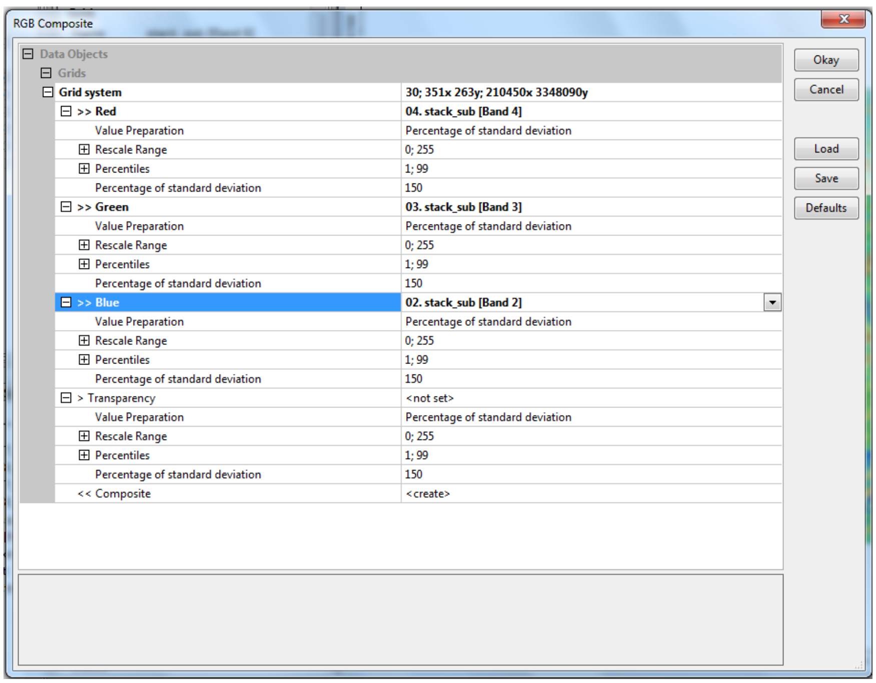
SAGA cannot handle multi-band imagery. The layers have to be viewed individually. Therefore, for every band combination, a false colour composite must be created as a separate image, or must overwrite a previous image.

Load the RGB Composite module via the Menu (Geoprocessing → Visualization → Grid → RGB Composite)

The 'RGB Composite' window will open in which will assign a band to each of the 3 colors. Click on the dropdown menu next to 'Grid System' and select the grid system to

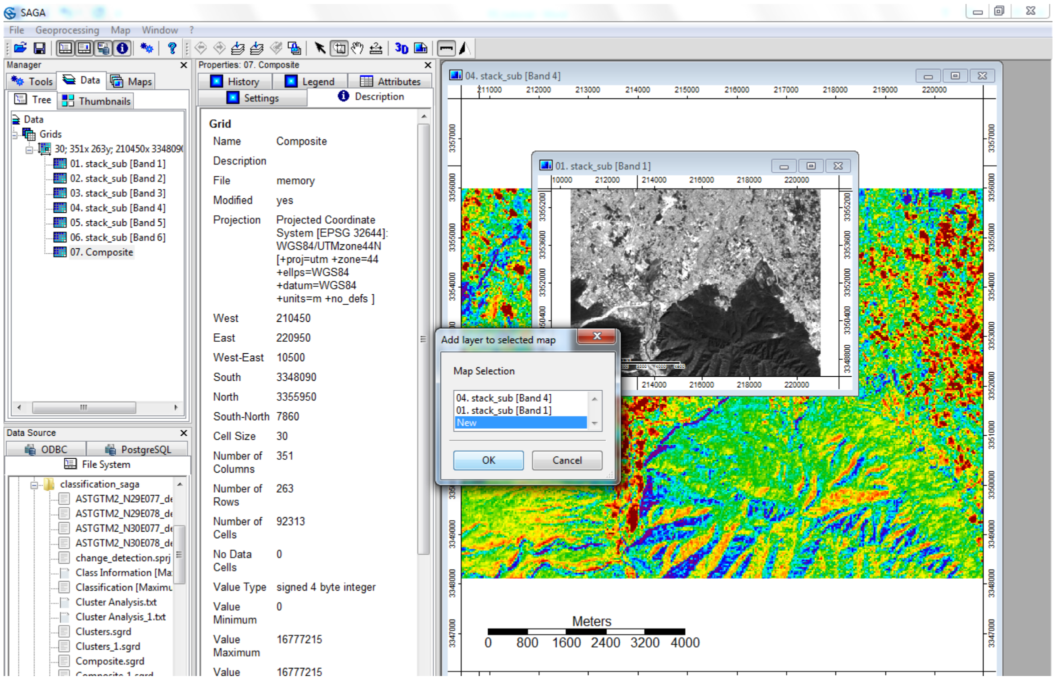
be used. Below this will be the entries for the colors. Using the dropdown menus select the appropriate bands for each colour. We will use the bands 4, 3 and 2 for Red, Green, and Blue respectively. Click 'Okay'.

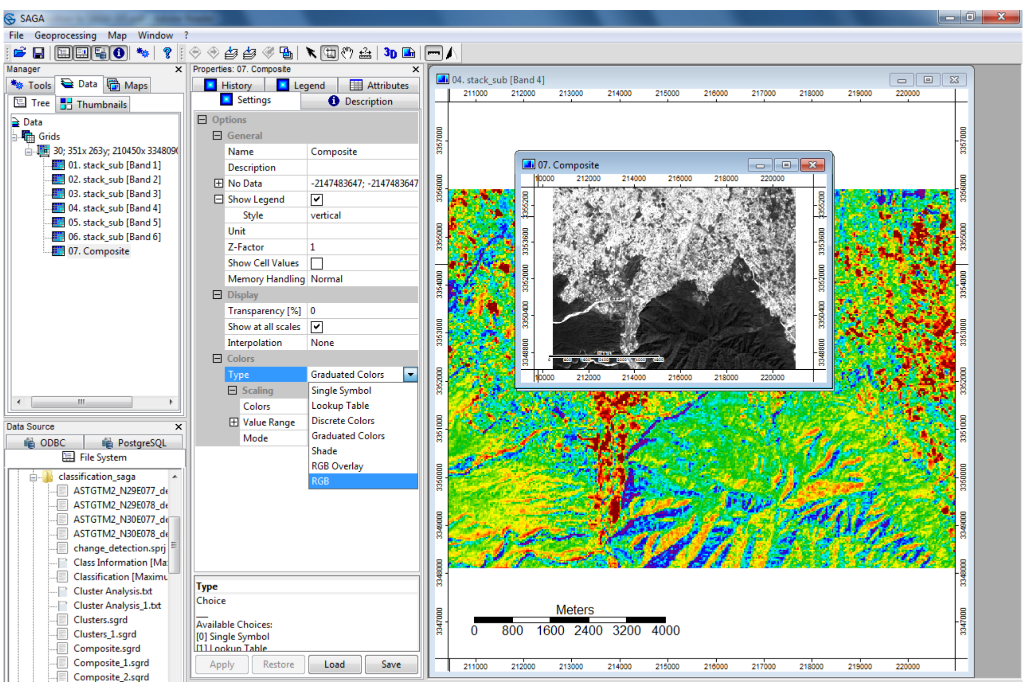


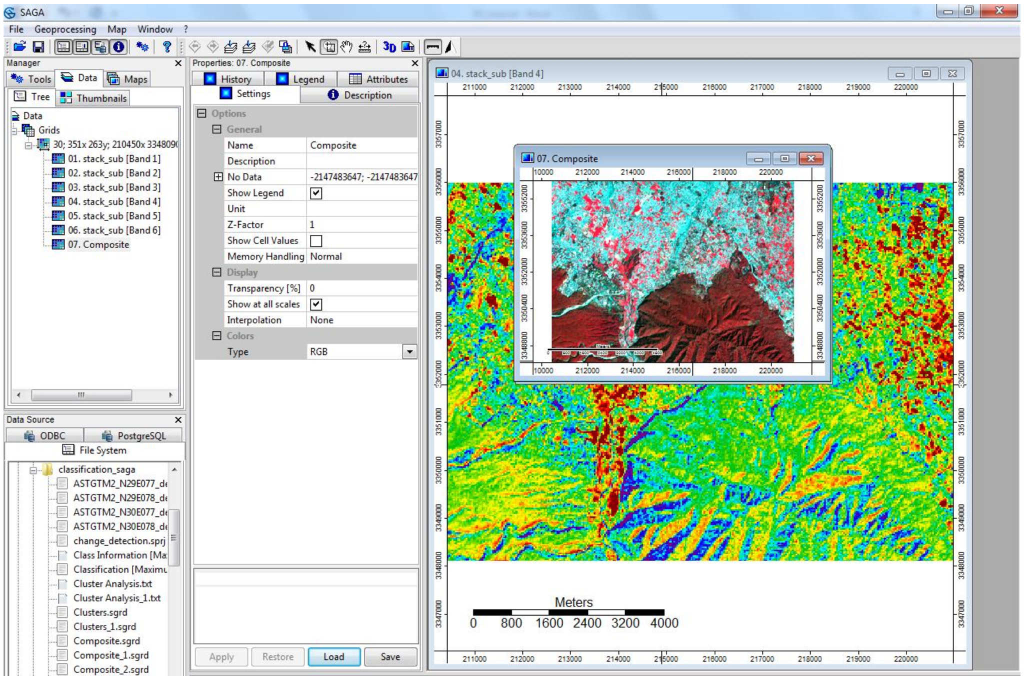


The composite is loaded into the same grid system as the rest of the layers. Click on the Data tab and double-click on the layer titled 'Composite'. Add it into a new map. The composite will like below.

If the Composite appears in grey ramp, go to the 'Settings' tab, under 'Colors' section select 'Type' as 'RGB Coded Values


SAGA
File Geoprocessing Map Window ?
Manager
Tools Data Maps
Tree Thumbnails
Data
Grids
30; 351x 263y; 210450x 334809
01. stack_sub [Band 1]
02. stack_sub [Band 2]
03. stack_sub [Band 3]
04. stack_sub [Band 4]
05. stack_sub [Band 5]
06. stack_sub [Band 6]
07. Composite
Data Source
ODBC PostgreSQL
File System
classification_saga
Cluster Analysis.txt
Cluster Analysis_1.txt
Clusters.sgrd
Clusters_1.sgrd
Composite.sgrd
Properties: 07. Composite
History Legend Attributes
Settings Description
Grid
Name Composite
Description
File memory
Modified yes
Projection Projected Coordinate System [EPSG 32644]: WGS84/UTMzone44N [+proj=utm +zone=44 +ellps=WGS84 +datum=WGS84 +units=m +no_defs]
West 210450
East 220950
West-East 10500
South 3348090
North 3355950
South-North 7860
Cell Size 30
Number of Columns 351
Number of Rows 263
Number of Cells 92313
No Data Cells 0
Value Type signed 4 byte integer
Value Minimum 0
Value Maximum 16777215
Value 16777215
04. stack_sub [Band 4]
01. stack_sub [Band 1]
Add layer to selected map
Map Selection
04. stack_sub [Band 4]
01. stack_sub [Band 1]
New
OK
Cancel
Meters
0 800 1600 2400 3200 4000

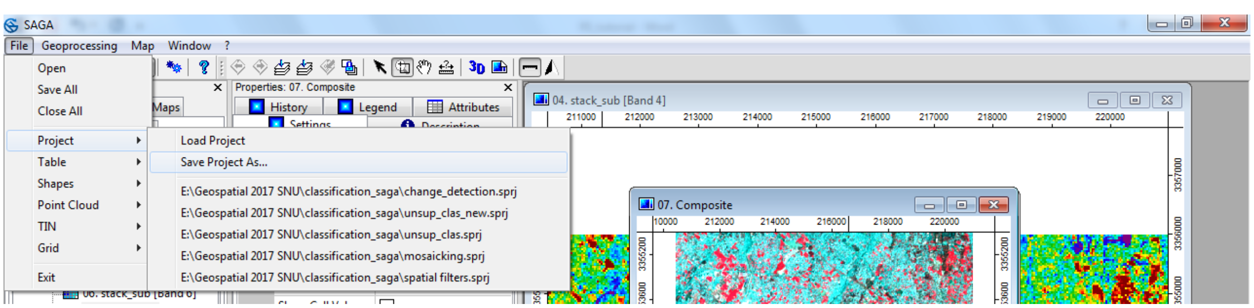

SAGA
File Geoprocessing Map Window ?
Manager
Tools Data Maps
Tree Thumbnails
Data
Grids
01. stack_sub [Band 1]
02. stack_sub [Band 2]
03. stack_sub [Band 3]
04. stack_sub [Band 4]
05. stack_sub [Band 5]
06. stack_sub [Band 6]
07. Composite
Properties: 07. Composite
History Legend Attributes
Settings Description
Options
General
Name Composite
Description
No Data -2147483647; -2147483647
Show Legend
Style vertical
Unit
Z-Factor 1
Show Cell Values
Memory Handling Normal
Display
Transparency [%] 0
Show at all scales
Interpolation None
Colors
Type Graduated Colors
Scaling
Colors
Value Range
Mode
Single Symbol
Lookup Table
Discrete Colors
Graduated Colors
Shade
RGB Overlay
RGB
Type
Choice
Available Choices:
[0] Single Symbol
Apply Restore Load Save
04. stack_sub [Band 4]
07. Composite
Meters
0 800 1600 2400 3200 4000

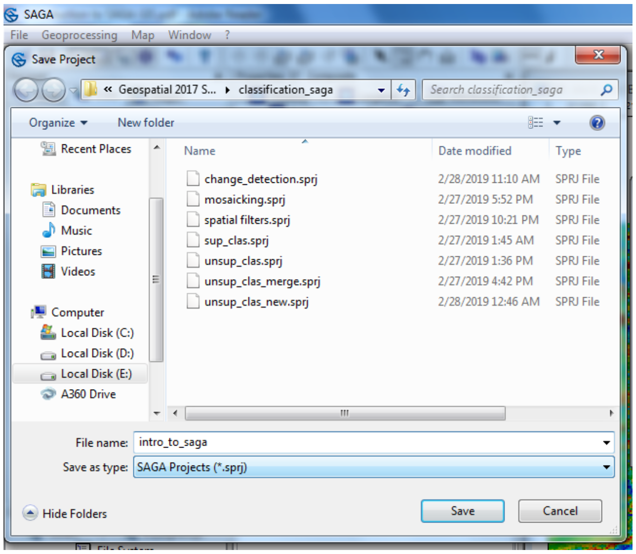


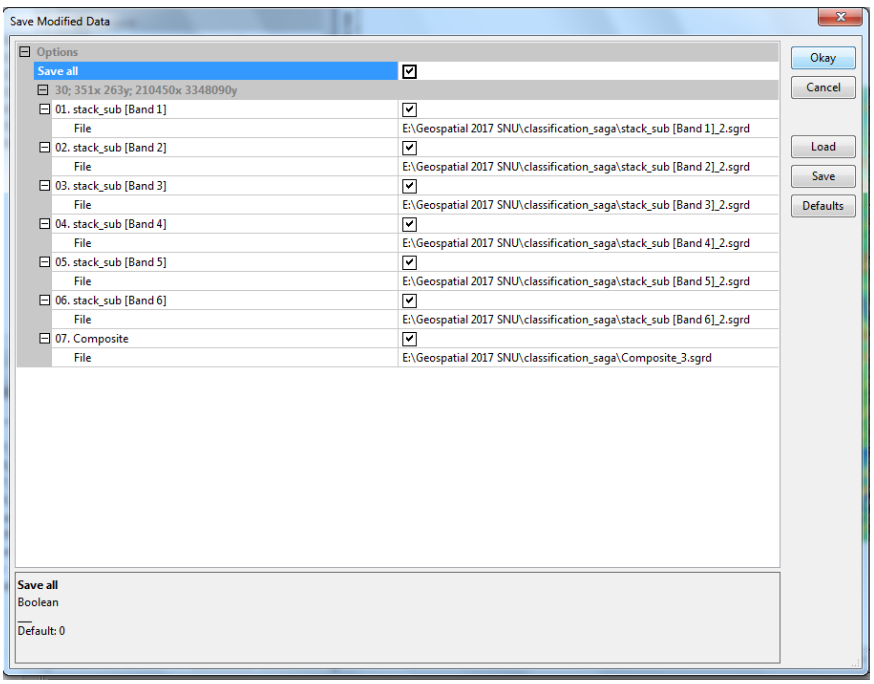
The composite makes it easier for us to interpret the image. For example, the red patches indicate the presence of vegetation, while the large cyan patched are built-up areas.

To change the band combinations run the 'RGB Composite' module again. From the Menu select ‘Geoprocessing’ and look at the last entry. It will display the most recently used processing module.

Now save the project via the Menu (File → Project → Save Project As), In the ‘Save AS’ popup window browse to the desired folder to save, and enter the desired name and click on ‘Save’. In the popup window check the Checkbox ‘Save all’ and click ‘Okay’







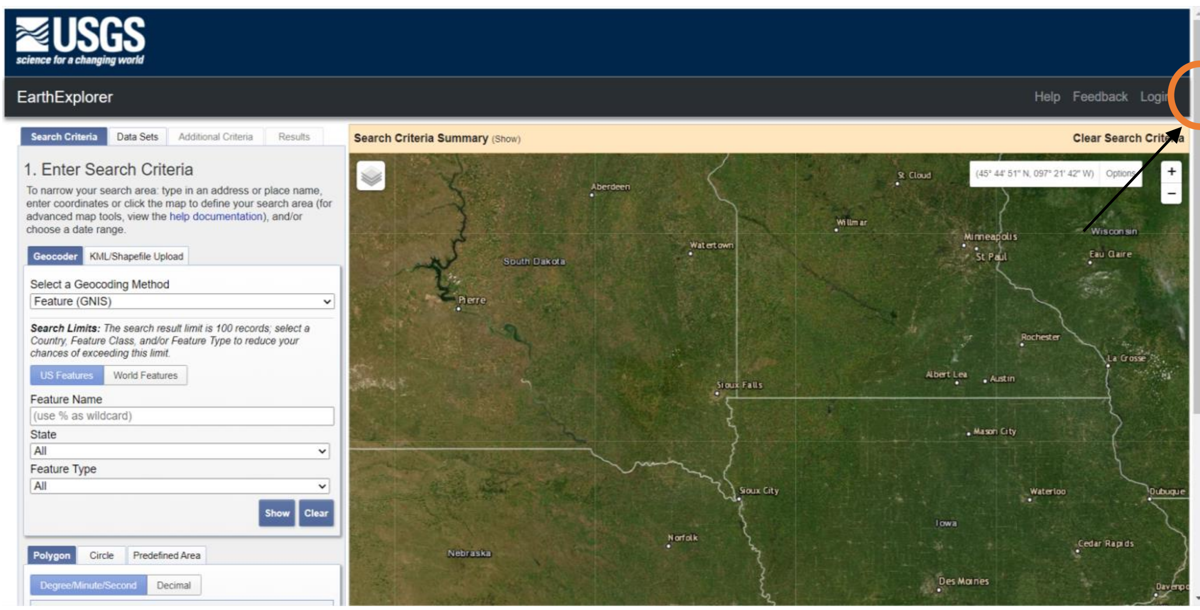
Task: Create RGB composites with 243, 254 and 324 combinations and describe the each composite usefulness over others to identify various land use/ cover.

DOWNLOADING SATELLITE DATA

To visualize and download satellite data from USGS Earth Explorer

The USGS EarthExplorer (EE) tool provides users to search, order satellite images, aerial photographs, and cartographic products from several sources like Landsat, Sentinel, Aster, MODIS, etc. In this tutorial, we will learn how to download Landsat 8 OLI satellite scene covering Jawaharlal Nehru University, New Delhi.

Step 1: Look for EarthExplorer in the search engine or go directly to the link provided below. https://earthexplorer.usgs.gov/



Note: Remember in order to download satellite images; you are required to create a login account. No login details are required to visualize data.

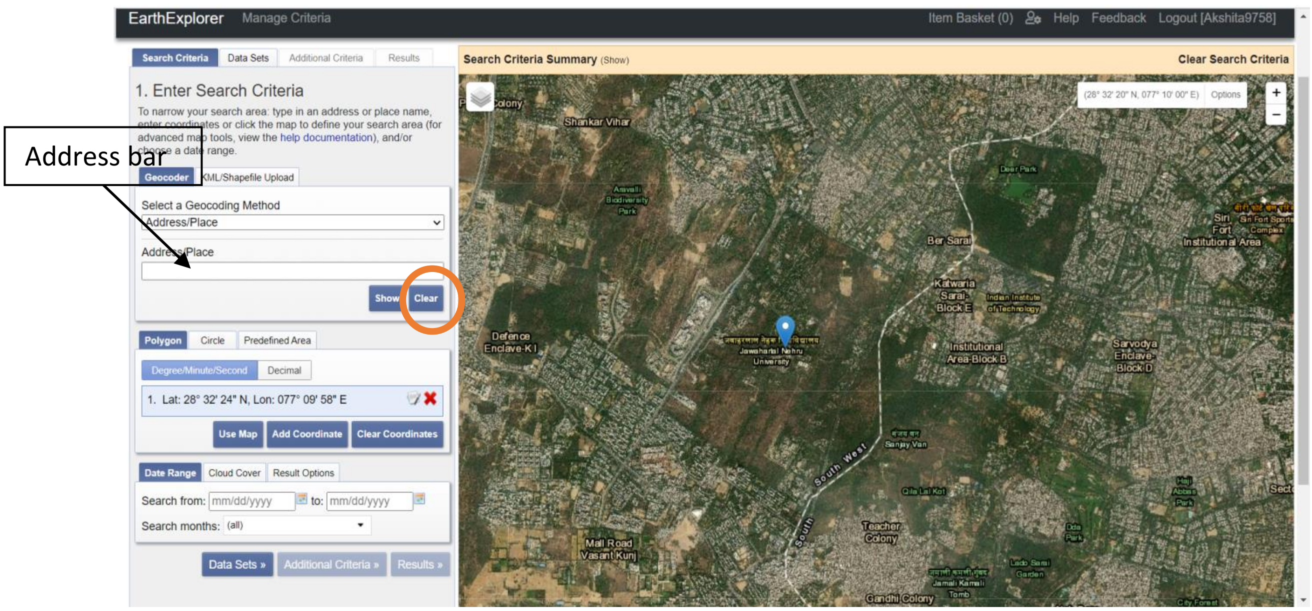
Step 2: Select a geocoding method. There are three ways to search area.

a) **Feature (GNIS)** – Geographic Name information system. GNIS contains information about the official names for places, features, and areas in the 50 states, the District of Columbia, and the territories and outlying areas of the United States, including Antarctica.

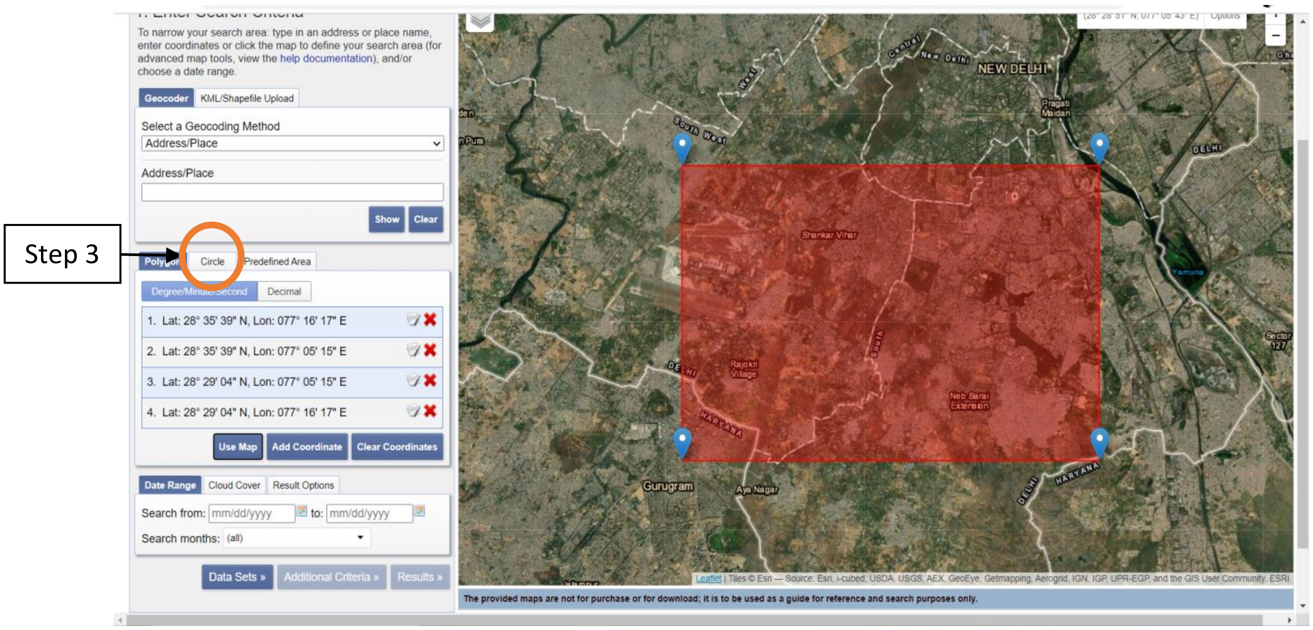
b) **Path/Row** - It is an address developed by Worldwide Reference System (WRS) for Landsat data. Refer to the provided link for more information. https://landsat.gsfc.nasa.gov/the-worldwide-reference-system/

c) **Address/Place** – It searches places, locations, cities, etc. by their names.

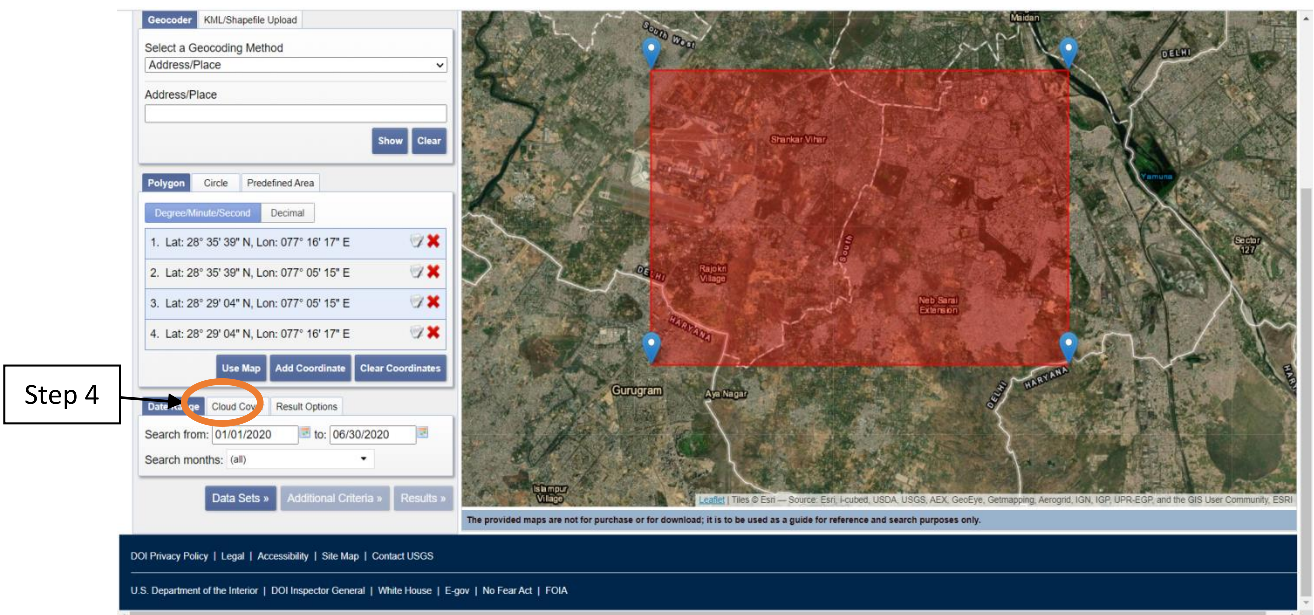
Simplest way is to go with 'Address/Place' option first and if the tool is unable to search with the name, choose Path/Row (Latitude/Longitude of any location can be converted to Path/Row). Input full name of university in the Address/Place box and click on 'show'.



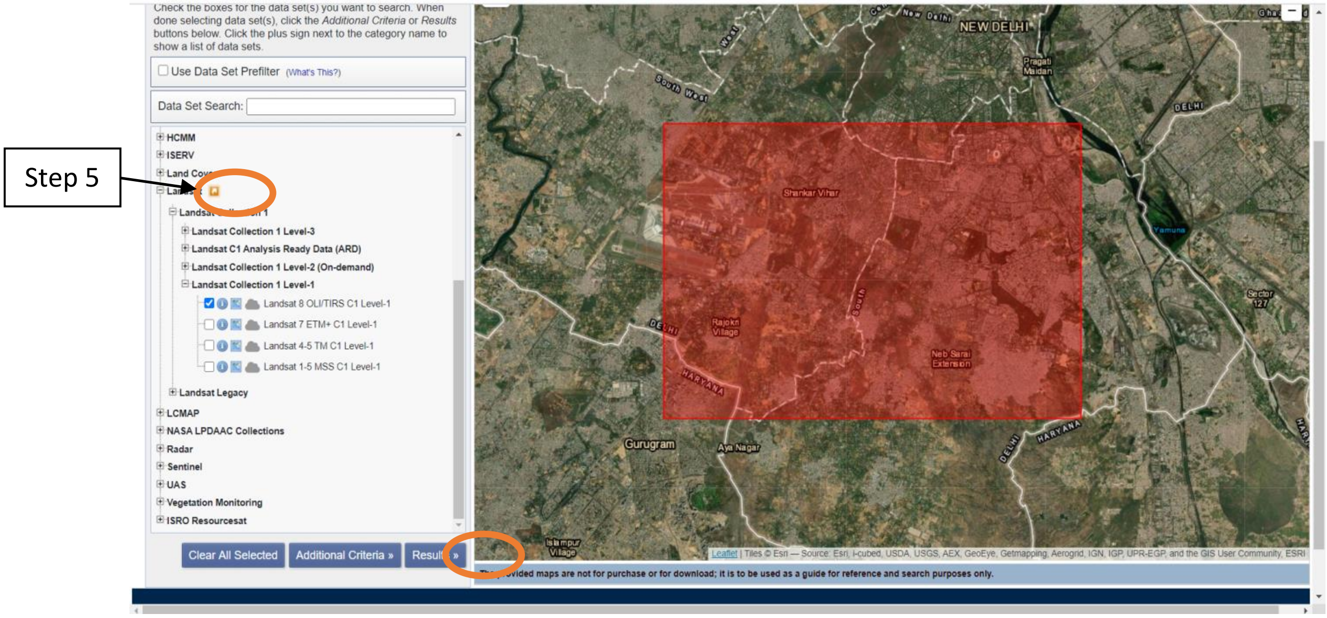
Step 3: Define a particular range of area to be covered by the image. You can use a **polygon draw a circle or upload a shapefile** of the desired location. In this tutorial, a polygon is used to highlight JNU and its surroundings.



Step 4: After selecting desired area, select the timeframe in the date range box. Move on to 'data sets' after filling the required date.

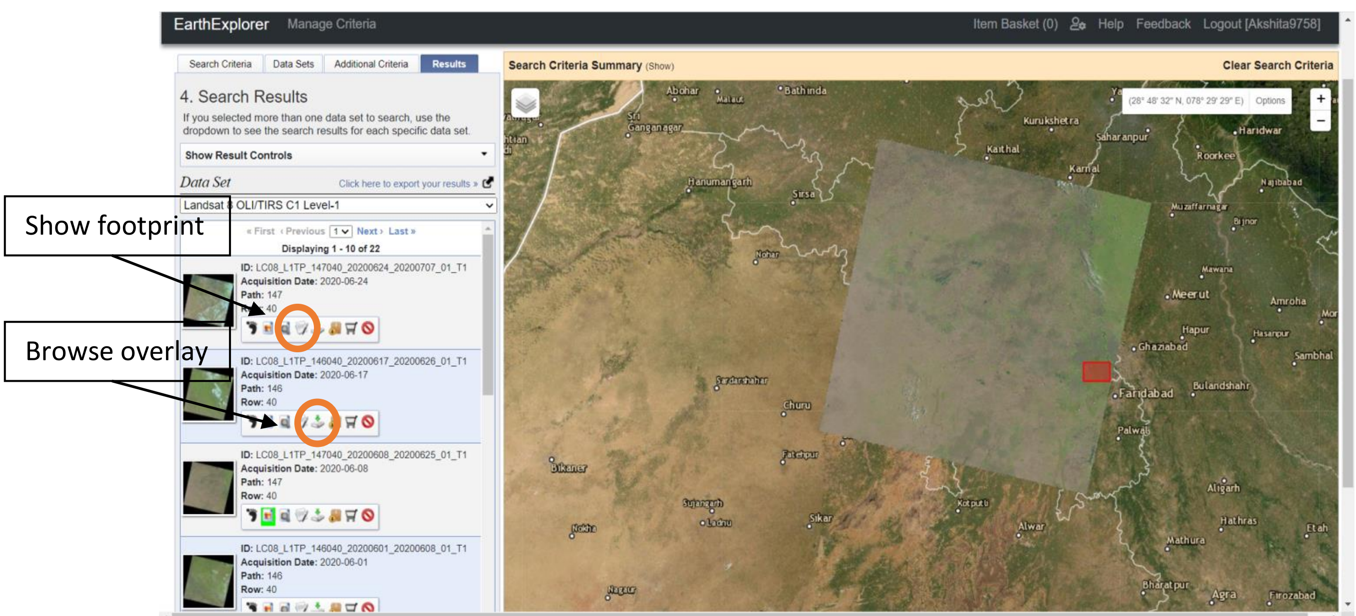


Step 5: Choose the data set you need from the list of data sets. In this case, we will select Landsat -> Landsat Collection 1 Level-1 -> Landsat 8 OLI/TIRS C1 Level-1. After selecting the data set, click on 'Results'.

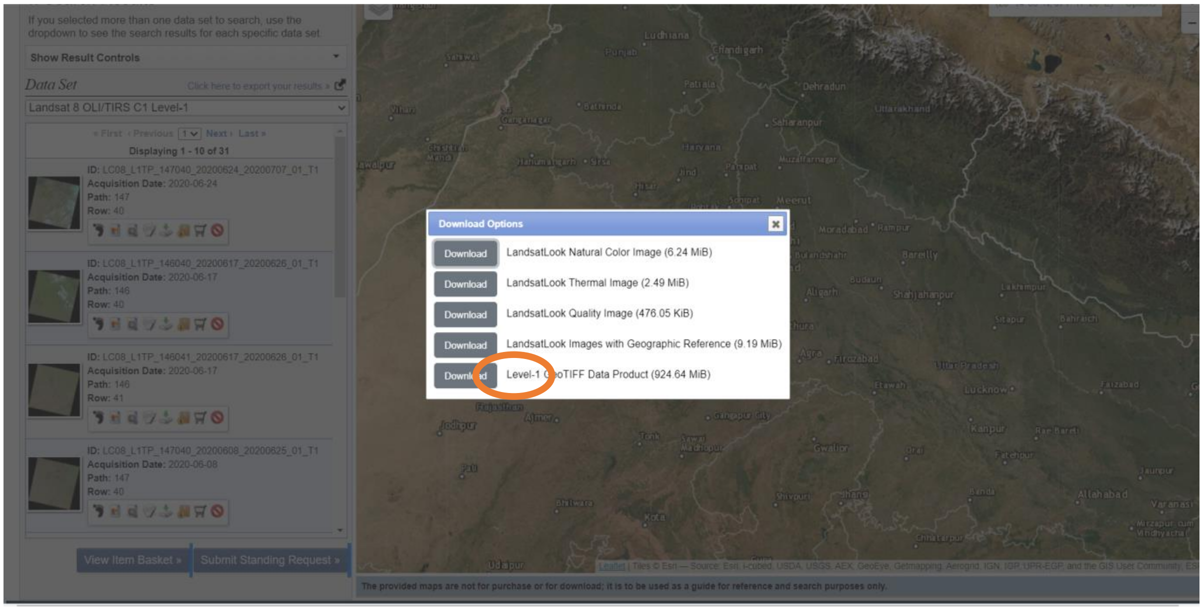


Note: Explore additional criteria if required. It is not mandatory.

Step 6: Result section will display the data sets available matching your criteria. Choose 'show footprint' or 'browse overlay' to check if the image covers your required area/polygon.



Step 7: To download the image, click on 'Download options'. Choose the type of image required for your study from the options.


Download Options
Download
LandsatLook Natural Color Image (6.24 MiB)
Download
LandsatLook Thermal Image (2.49 MiB)
Download
LandsatLook Quality Image (476.05 KiB)
Download
LandsatLook Images with Geographic Reference (9.19 MiB)
Level-1 GeoTIFF Data Product (924.64 MiB)
Show Result Controls
Data Set
Landsat 8 OLI/TIRS C1 Level-1
Displaying 1 - 10 of 31
View Item Basket »
Submit Standing Request »

UNDERSTANDING AN IMAGE

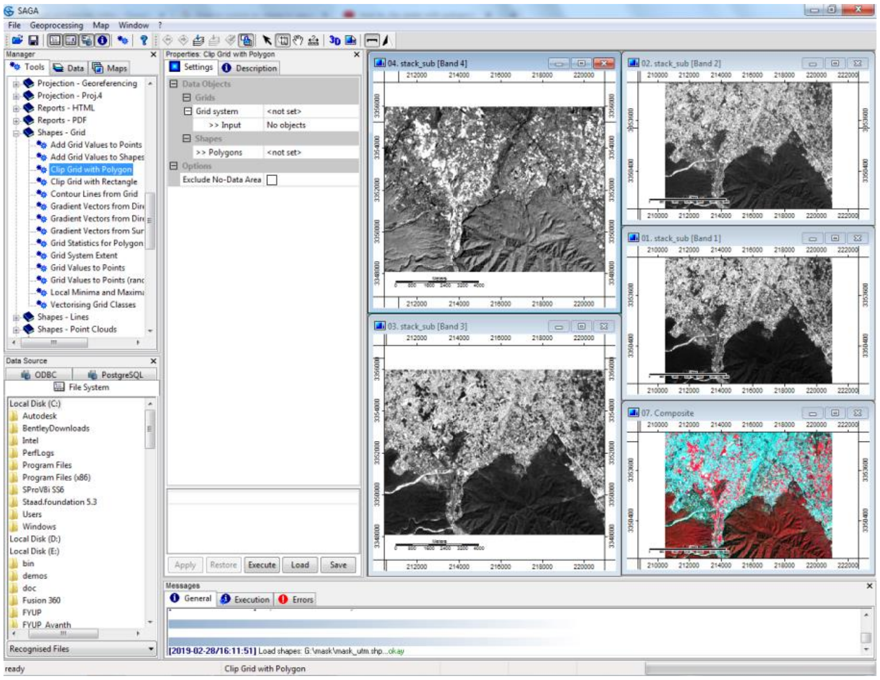
Introduction

Satellite or airborne digital images are composed of a two-dimensional array of discrete picture elements, known as pixels. Generally, the pixels in remote sensing images are in square shape. The corresponding length of a side of the pixel on earth surface is known as ground sampling distance or simply 'spatial resolution'. Each pixel is associated with a spectral brightness value (also, known as Digital Number, simply 'DN') of corresponding ground feature. These DN values are a quantized spectral radiance1 of a specific wavelength received at the sensor. The value range of Digital numbers in an image is determined by the radiometric resolution. For example, a sensor with 8-bit radiometric resolution permits maximum 28 i.e., 256 DN values (brightness values or gray scale levels) ranging from 0-255. A pixel with high DN value represents that the sensor received high spectral radiance from the corresponding ground area of the pixel and vice versa. In order to acquire sufficient spectral information of an objects on the earth surface, a set of sampling wavelengths in the electromagnetic spectrum are used. The sensor will record the DN values which are specific to these sampling wave lengths. Therefore, each sampling wavelength will result an array of pixels and is known as a band of satellite image. If a sensor uses one wider wavelength range (i.e, ≈ 0.4 µm to 0.7 µm) to measure the spectral response characteristics of an area, then it records all the information into one single image band, such sensors are known as 'panchromatic sensors' and the satellite image is known a 'panchromatic satellite image'. A multispectral sensor collects the spectral information using few number of sampling wavelengths in electromagnetic spectrum, hence it is a multi-layer (multi band) image. For example, Landsat-8 sensor records the spectral information in eleven image bands, for more information please refer http://landsat.usgs.gov/band_designations_landsat_satellites.php.

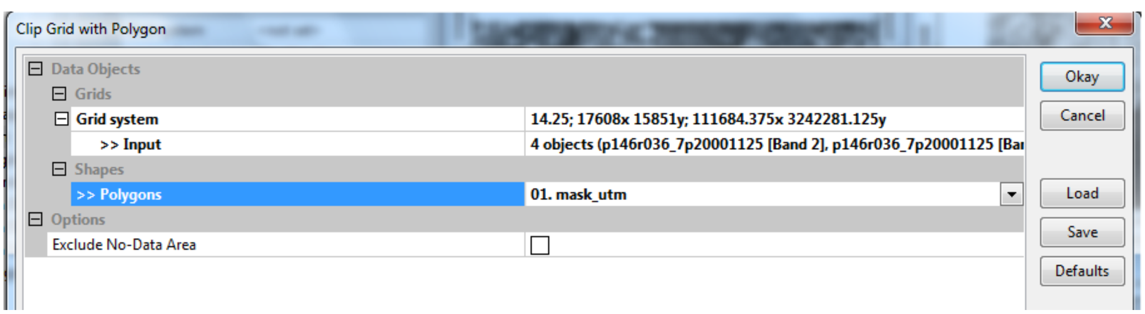
The tutorial dataset is a stacked image of landsat 8, used in tutorial "Introduction to SAGA". OR you can use the dataset you have just downloaded in the previous exercise.

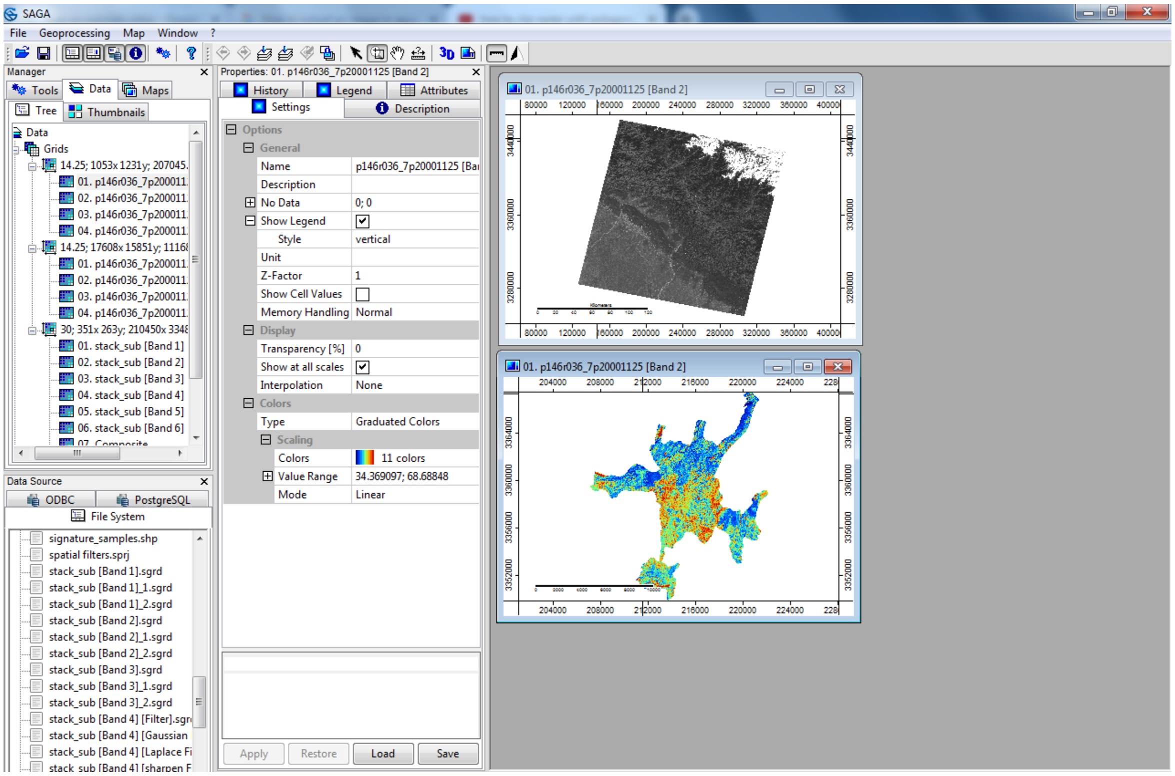
To view image bands double click on the Image bands under 'Data' tab in 'Manager' section. In order to open them in separate viewers, make sure to select option 'New' in 'Add layer to selected map' window when it prompt. And change the colour ramp to grey scale (Refer: previous tutorial)

Before proceeding further, tile the viewers via, 'Windows→Tile Horizontally. And synchronize the extents via, Map→Synchronize Map Extents.

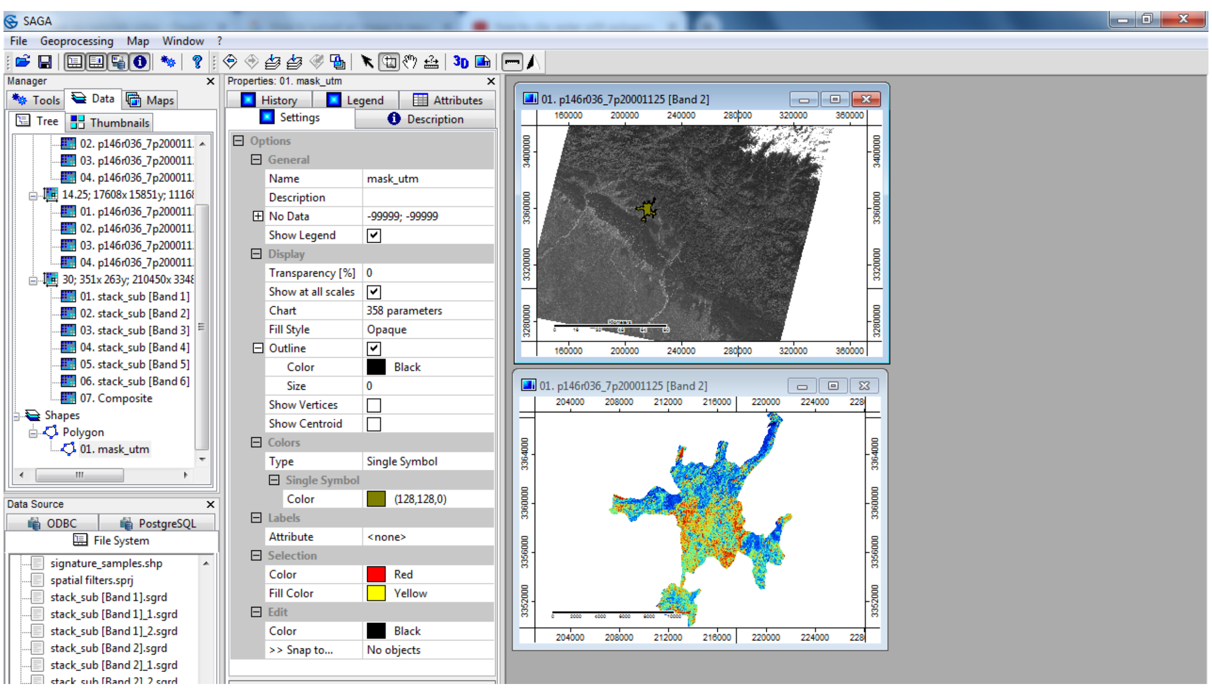


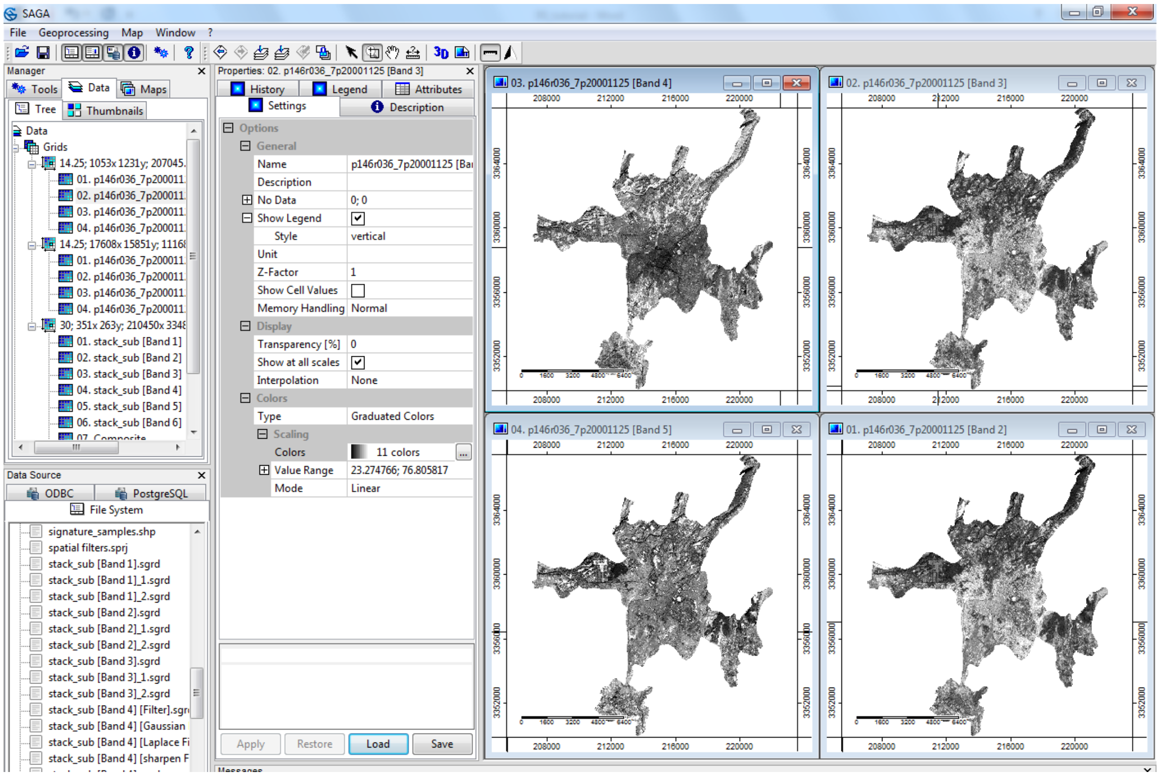
Sub-setting using polygon





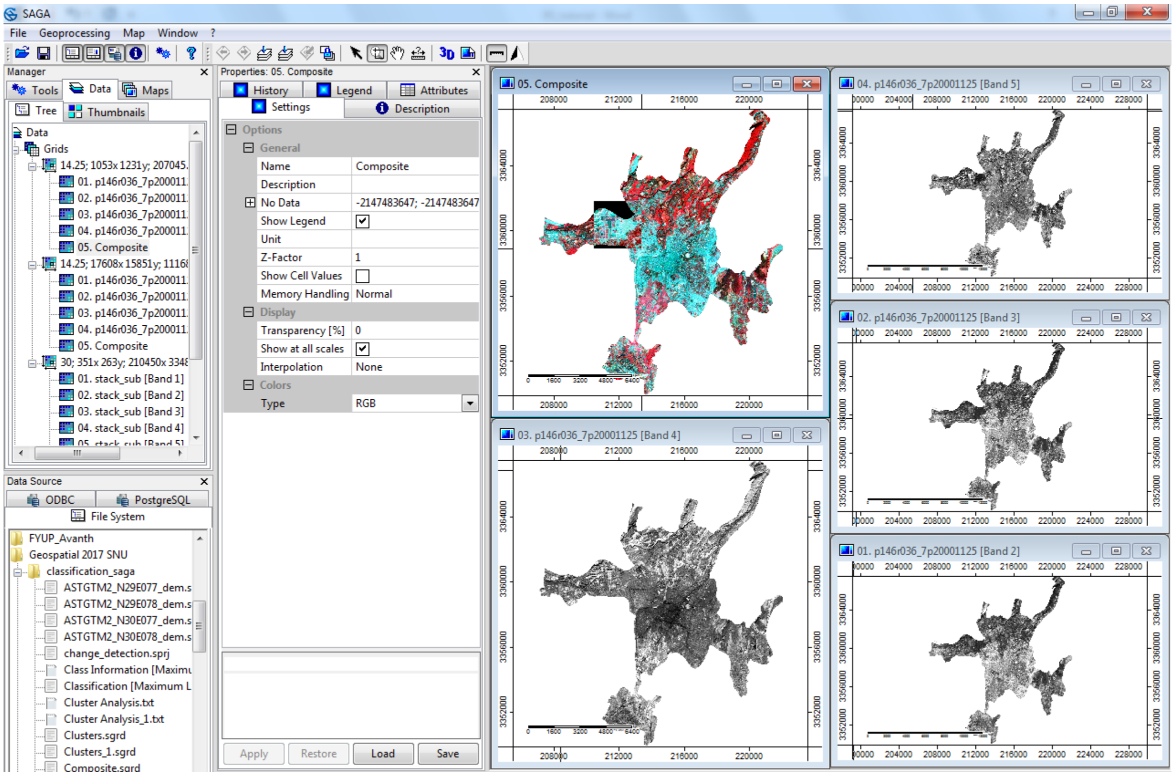
Add the shapefile to same layer as the raster image to see its location on the satellite data.



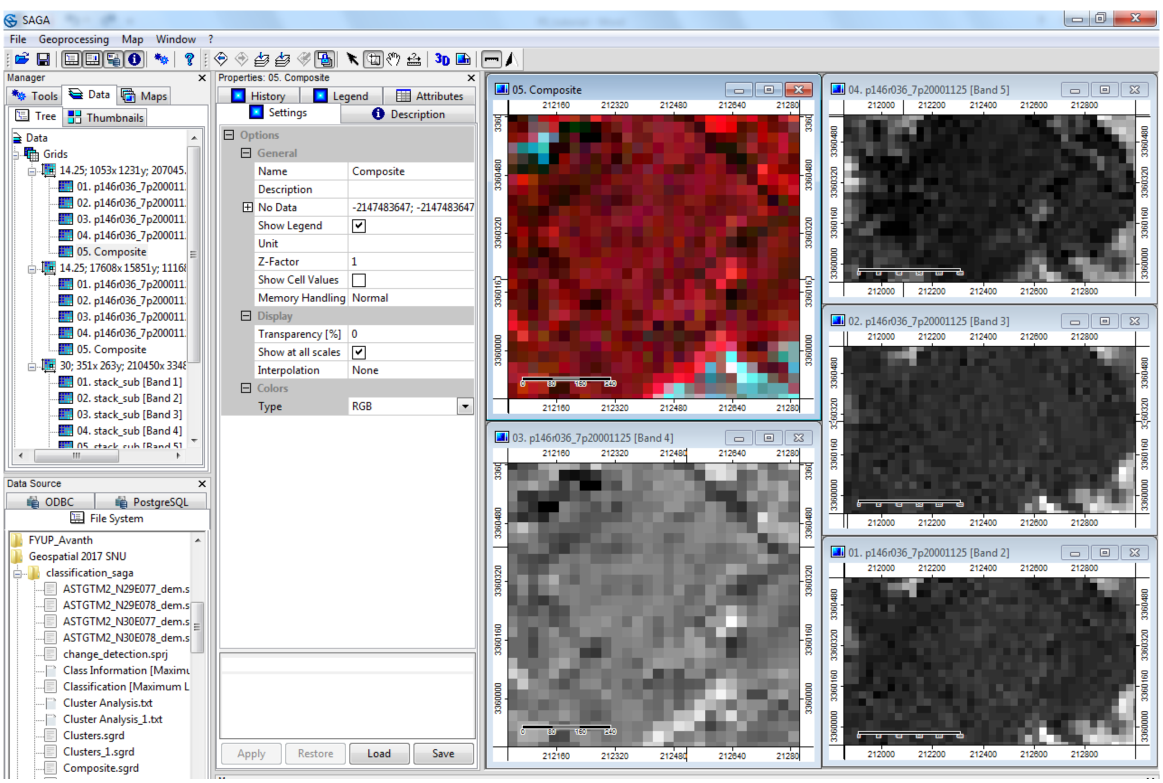


If a grey scale (Black to white) colour ramp used to represent the image. Then black colour represents less, grey colour represents medium and white colour represents high spectral returns from the earth surface features. Zoom to various land-cover classes i.e., water, urban areas, and agriculture etc., and try to explore the brightness values (DN) in terms of spectral response of land-cover classes for the individual bands. Write down the relative spectral response as 'low', 'medium' or 'high', for the different land cover classes and spectral bands.

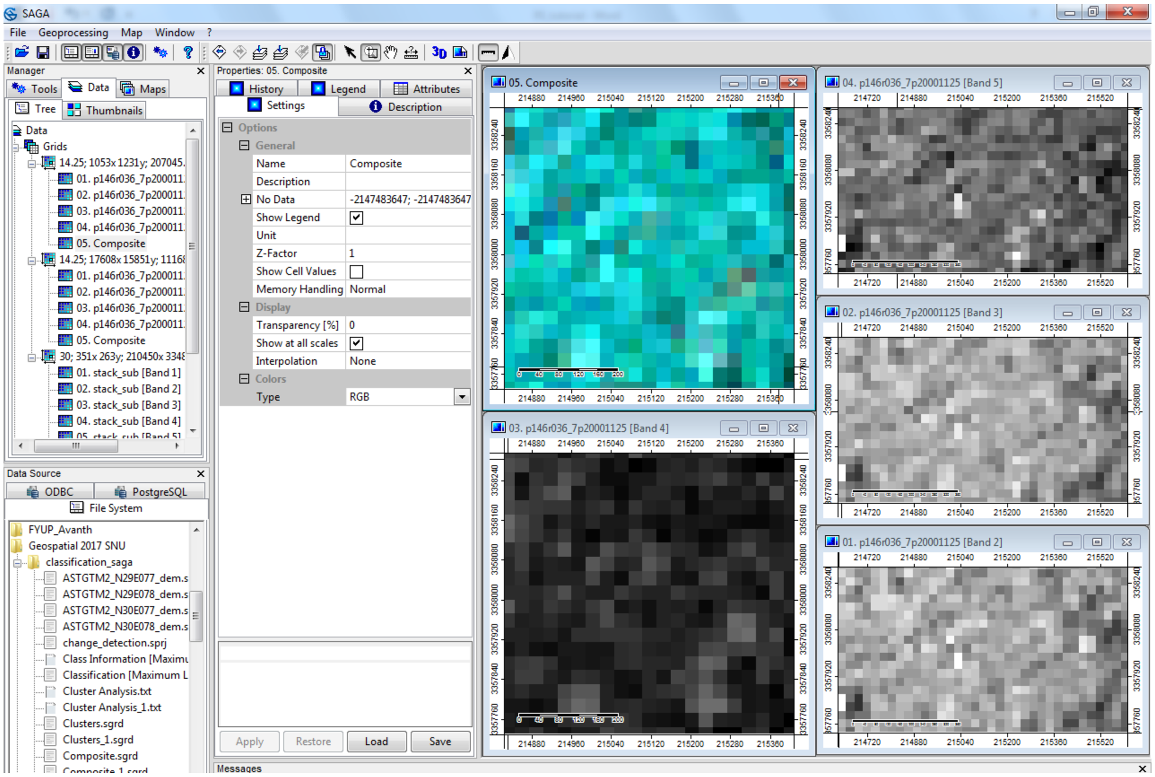
	Forest	Built-up area	Agriculture
Band 2			
Band 3			
Band4			
Band5			


SAGA
File Geoprocessing Map Window ?
Manager
Tools Data Maps
Tree Thumbnails
Properties: 05. Composite
History Legend Attributes
Settings Description
Options
General
Name Composite
Description
No Data -2147483647; -2147483647
Show Legend
Unit
Z-Factor 1
Show Cell Values
Memory Handling Normal
Display
Transparency [%] 0
Show at all scales
Interpolation None
Colors
Type RGB
Apply Restore Load Save
Data Source
ODBC PostgreSQL
File System
FYUP_Avanth
Geospatial 2017 SNU
classification_saga
change_detection.sprj
Cluster Analysis.txt
Cluster Analysis_1.txt
Clusters.sgrd
Clusters_1.sgrd
05. Composite
04. p146r036_7p20001125 [Band 5]
02. p146r036_7p20001125 [Band 3]
03. p146r036_7p20001125 [Band 4]
01. p146r036_7p20001125 [Band 2]

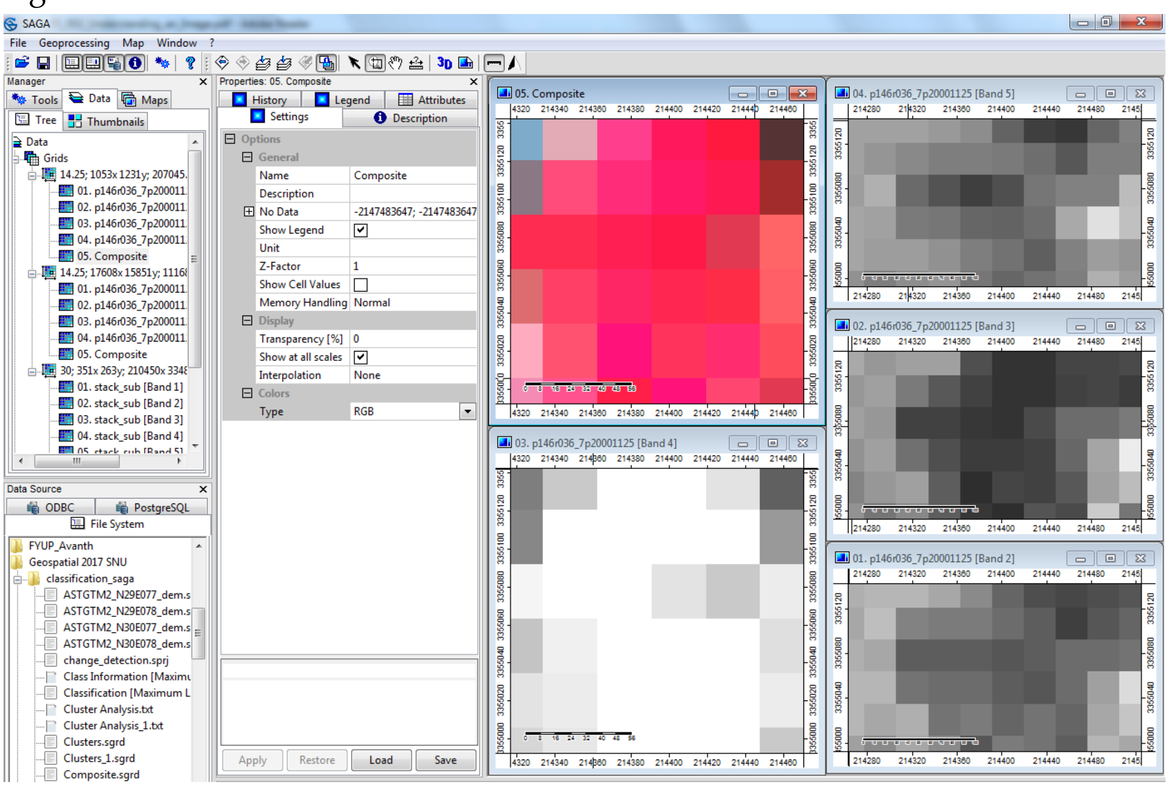
Green cover


SAGA
File Geoprocessing Map Window ?
Manager
Tools Data Maps
Tree Thumbnails
Properties: 05. Composite
History Legend Attributes
Settings Description
Options
General
Name Composite
Description
No Data -2147483647; -2147483647
Show Legend
Unit
Z-Factor 1
Show Cell Values
Memory Handling Normal
Display
Transparency [%] 0
Show at all scales
Interpolation None
Colors
Type RGB
Apply Restore Load Save
Data Source
ODBC PostgreSQL
File System
FYUP_Avanth
Geospatial 2017 SNU
classification_saga
change_detection.sprj
Cluster Analysis.txt
Cluster Analysis_1.txt
Clusters.sgrd
Clusters_1.sgrd
Composite.sgrd
05. Composite
04. p146r036_7p20001125 [Band 5]
02. p146r036_7p20001125 [Band 3]
03. p146r036_7p20001125 [Band 4]
01. p146r036_7p20001125 [Band 2]

Built-up areas



Agriculture



Band Statistics

The distribution of brightness values (DN values) in a single band can be represented graphically using a histogram. The correlation between two (or more) bands can be assessed graphically by using a scatter plot. Large negative values indicate a strong negative correlation where as large positive values indicate strong positive relation and covariance values near to zero indicate no correlation. In this section, we will explore the image band data characteristics by using graphical methods.

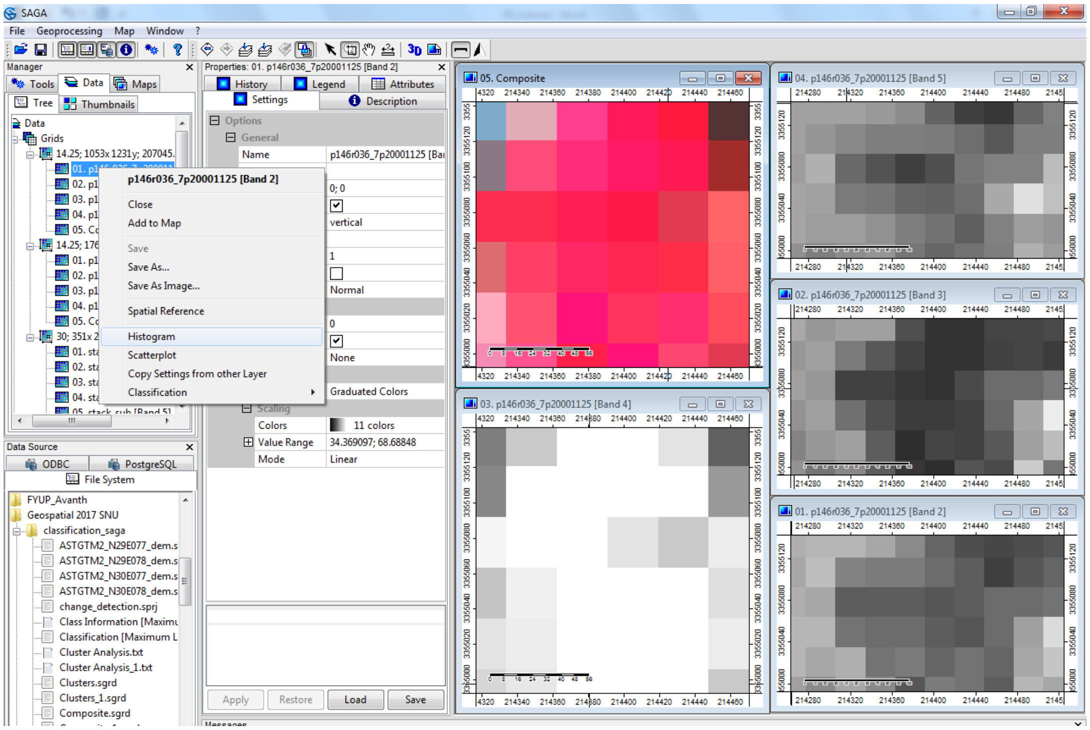
Graphical Representation

Histogram

The study of histogram provides initial information about the most important parameter of an image, i.e., contrast. Histogram is a frequency distribution function of DN values, which provides the information about number of pixels having a particular Digital Number. It can describe an image just in statistical terms without even explaining its spatial patterns.

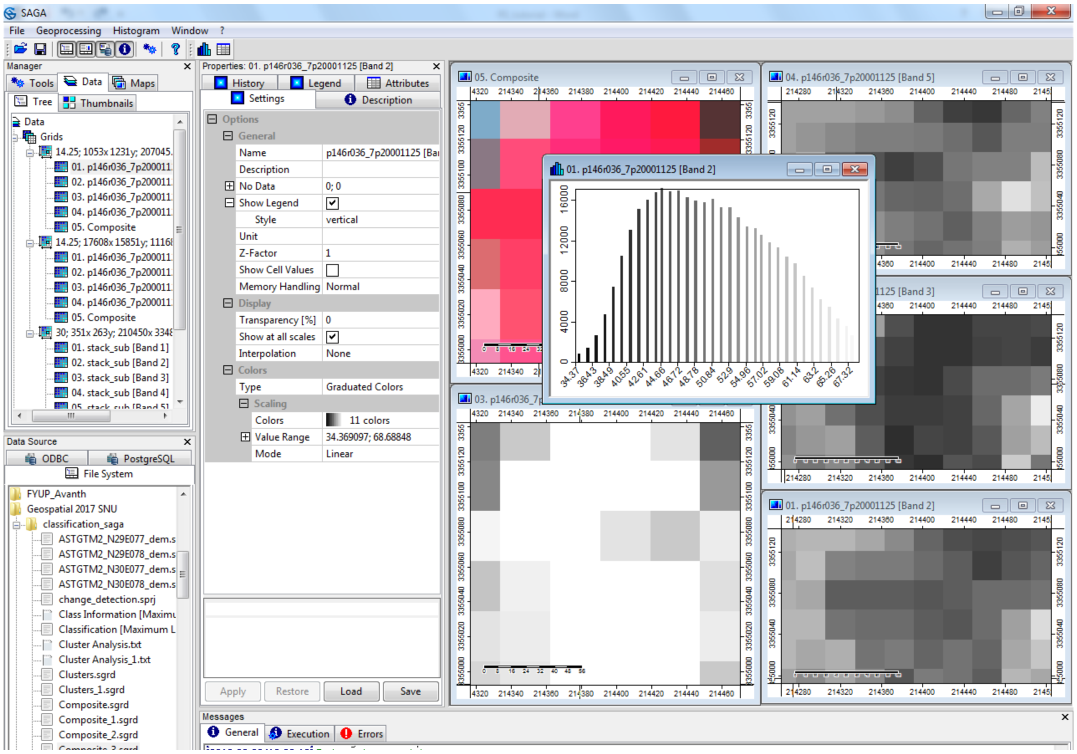
Histogram can be calculated for each band by just right clicking on the image band under Data Tab in Manager section, and select 'Histogram'. A new window will popup showing the histogram of the image band selected.

You can zoom in or out of the histogram extent using scroll key of mouse and also by dragging mouse with left data button and reset by right data button of mouse



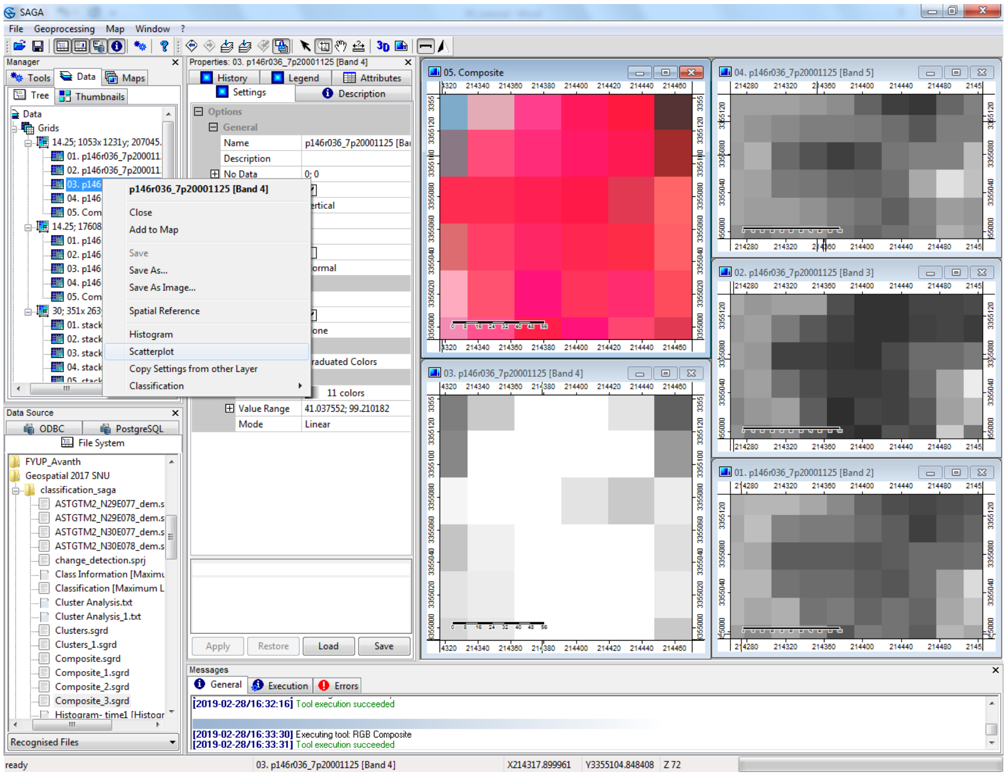
Follow similar steps to open up histogram for rest of three bands. Open four windows simultaneously side by side to see the frequency distribution of DN values in each band.

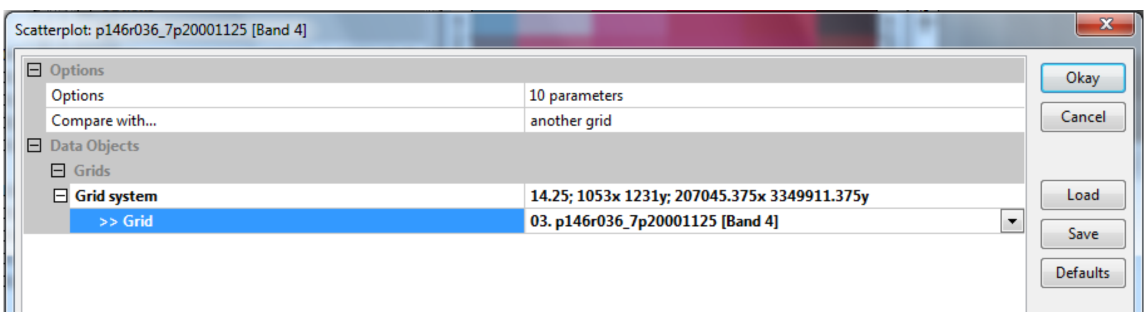
All the four image bands cover the same area with same extent. However, you can see different shape and sizes of band histograms. As explained earlier these differences are due to objects ability to respond differently with different spectral wavelengths.



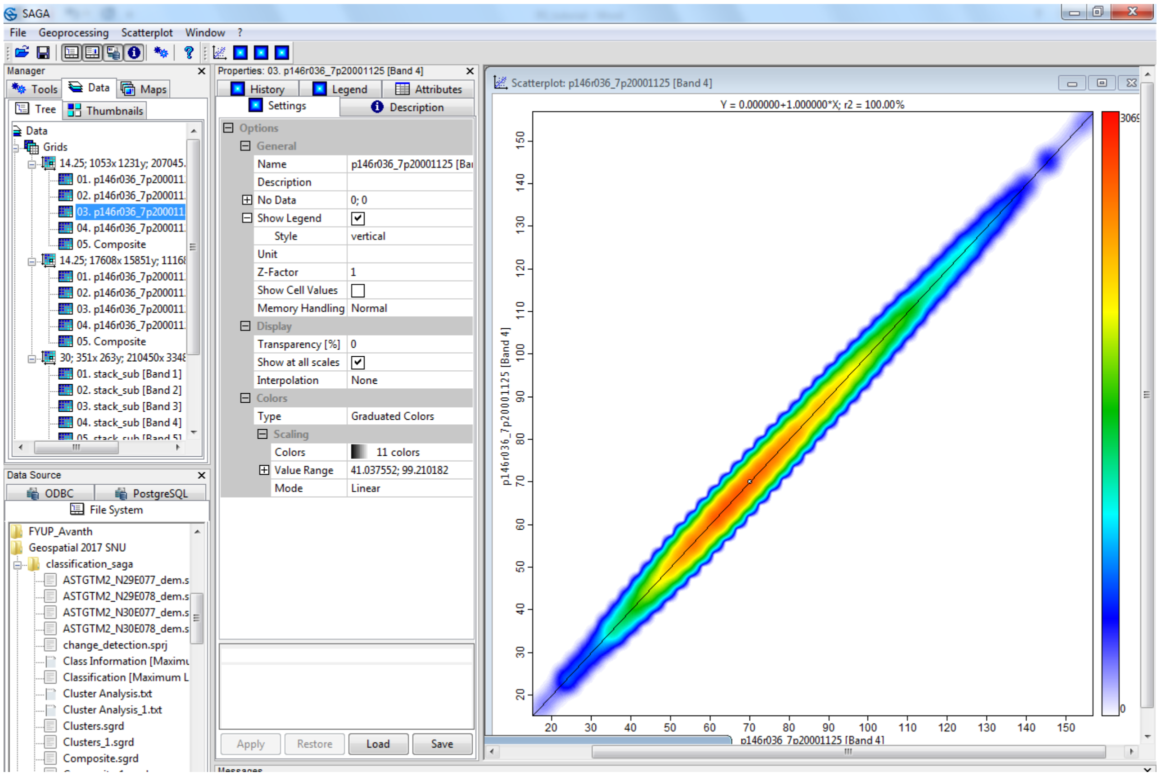
A scatterplot is simply a graph of the DN values of one band plotted against the DN values of another band. If the DN value in the image bands follows normal distribution, then the corresponding feature space of scatterplot will form an ellipse. The feature space in scatter plot is very useful to select the training samples and also helpful to for principal components. In a Bi-dimensional scatterplot, the Cartesian axes (X, Y) represents the Digital Numbers of the two bands in interest, Z axis represents the frequency of occurrence of certain phenomenon. In this section we will learn how to construct scatterplot.

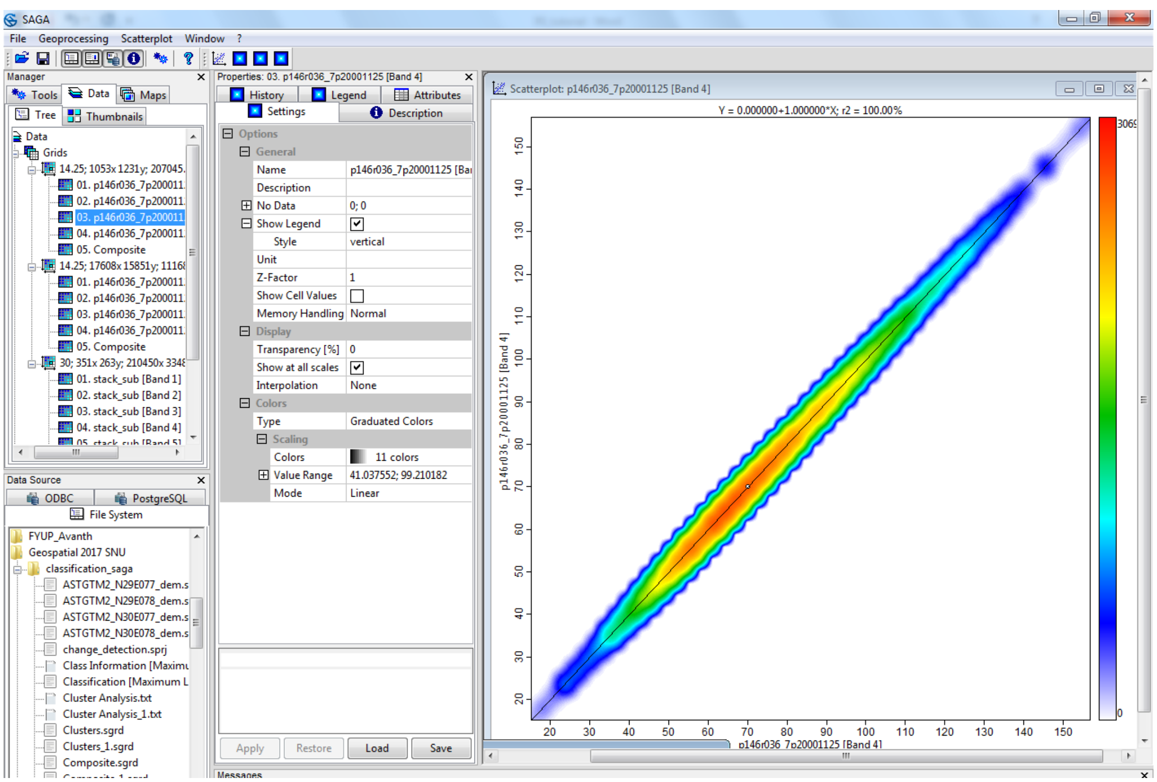
Right click on Band3 under Data tab in Manager section and select Scatterplot. It will prompt a new window, now select options as shown in below figure and click ‘OK’.

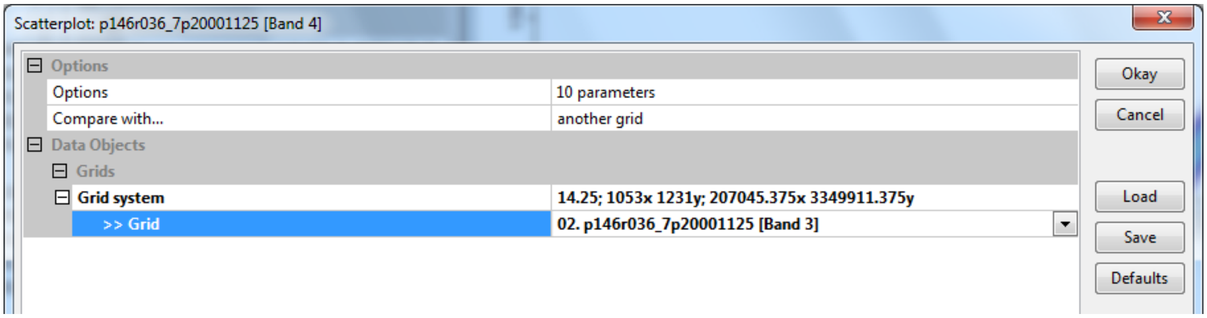




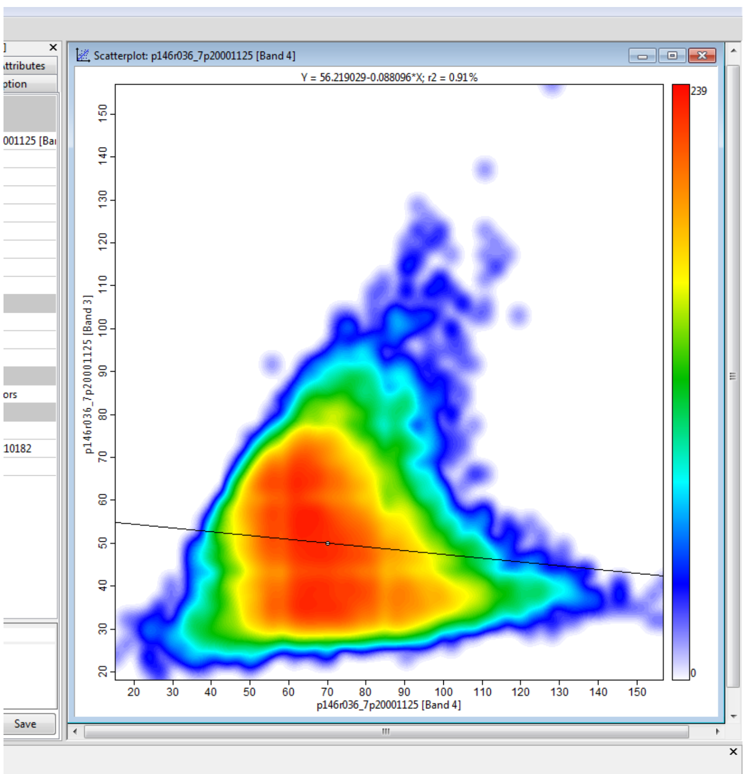
Scatter plot of band 4 with band 4 is displayed.


SAGA
File Geoprocessing Scatterplot Window ?
Manager
Tools Data Maps
Tree Thumbnails
Data
Grids
14.25; 1053x 1231y; 207045.
01. p146r036_7p200011
02. p146r036_7p200011
03. p146r036_7p200011
04. p146r036_7p200011
05. Composite
14.25; 17608x 15851y; 1116
01. p146r036_7p200011
02. p146r036_7p200011
03. p146r036_7p200011
04. p146r036_7p200011
05. Composite
30; 351x 263y; 210450x 334
01. stack_sub [Band 1]
02. stack_sub [Band 2]
03. stack_sub [Band 3]
04. stack_sub [Band 4]
Data Source
ODBC PostgreSQL
File System
FYUP_Avanth
Geospatial 2017 SNU
classification_saga
ASTGTM2_N29E077_dem.s
ASTGTM2_N29E078_dem.s
ASTGTM2_N30E077_dem.s
ASTGTM2_N30E078_dem.s
change_detection.sprj
Class Information [Maximu
Classification [Maximum L
Cluster Analysis.txt
Cluster Analysis_1.txt
Clusters.sgrd
Clusters_1.sgrd
Composite.sgrd
Properties: 03. p146r036_7p20001125 [Band 4]
History Legend Attributes
Settings Description
Options
General
Name p146r036_7p20001125 [Ba
Description
No Data 0; 0
Show Legend
Style vertical
Unit
Z-Factor 1
Show Cell Values
Memory Handling Normal
Display
Transparency [%] 0
Show at all scales
Interpolation None
Colors
Type Graduated Colors
Scaling
Colors 11 colors
Value Range 41.037552; 99.210182
Mode Linear
Apply Restore Load Save
Messages
Scatterplot: p146r036_7p20001125 [Band 4]
Y = 0.000000+1.000000*X; r2 = 100.00%
p146r036_7p20001125 [Band 4]
p146r036_7p20001125 [Band 4]


SAGA
File Geoprocessing Scatterplot Window ?
Properties: 03. p146r036_7p20001125 [Band 4]
Scatterplot: p146r036_7p20001125 [Band 4]
Y = 0.000000+1.000000*X; r2 = 100.00%
p146r036_7p20001125 [Band 4]
p146r036_7p20001125 [Band 4]
Value Range 41.037552; 99.210182
Apply Restore Load Save

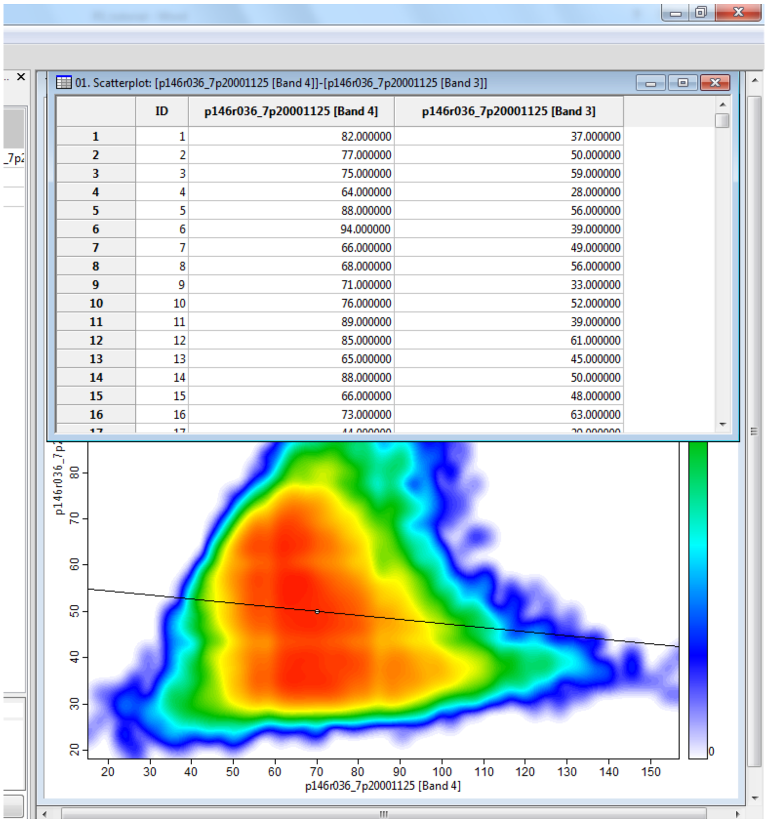


Scatter plot of Band 4 with Band 3



Now you can see the scatterplot of Band 4 vs Band 3 in a map layout. The X axis of scatterplot represents Band 3 while y-axis represents Band 4. It also gives the regression equation between the two bands along with correlation coefficient.

We can compute the scatter plot data in form of table. Goto 'Menu bar→Scatterplot→Convert to Table and have a look at mean, minimum, maximum, standard deviation values using the description table of object properties window.



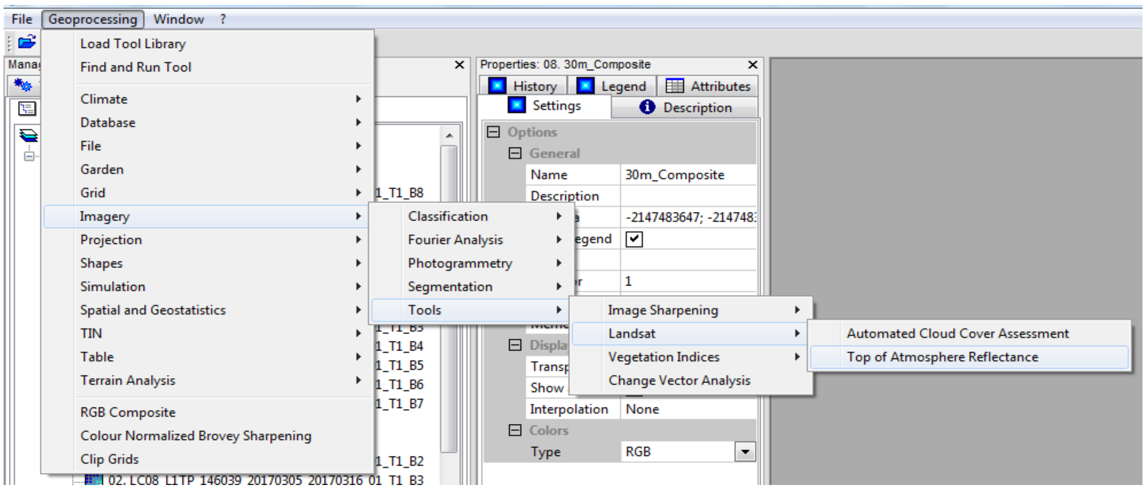
	ID	p146r036_7p20001125 [Band 4]	p146r036_7p20001125 [Band 3]
1	1	82.000000	37.000000
2	2	77.000000	50.000000
3	3	75.000000	59.000000
4	4	64.000000	28.000000
5	5	88.000000	56.000000
6	6	94.000000	39.000000
7	7	66.000000	49.000000
8	8	68.000000	56.000000
9	9	71.000000	33.000000
10	10	76.000000	52.000000
11	11	89.000000	39.000000
12	12	85.000000	61.000000
13	13	65.000000	45.000000
14	14	88.000000	50.000000
15	15	66.000000	48.000000
16	16	73.000000	63.000000

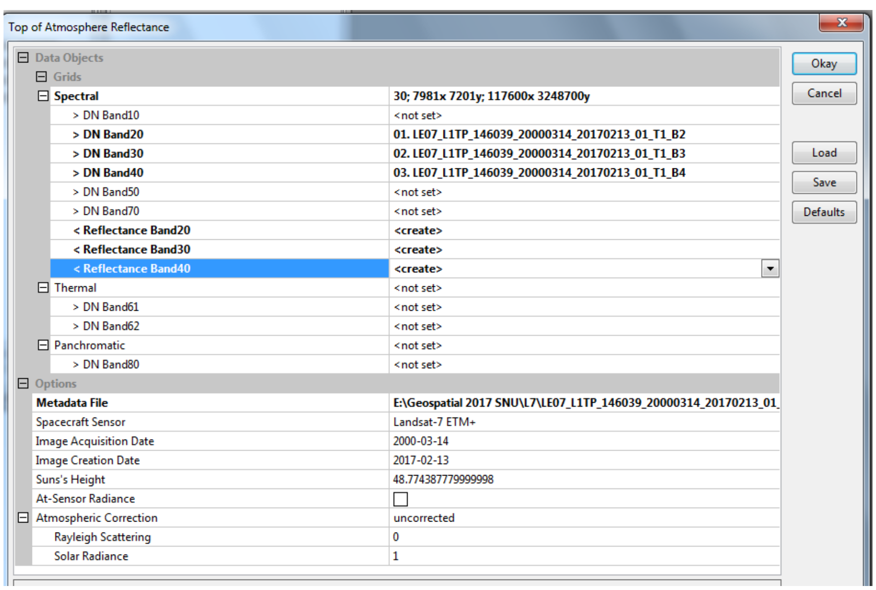
IMAGE PRE-PROCESSING

Atmospheric Correction

Top of Atmosphere correction converts Landsat imagery reflectance by removing variation due to solar irradiance. Load band 2-4 of the data provided to you in the folder L7. Then go to

Geoprocessing>Imagery>Landsat>Top Of Atmosphere Reflectance

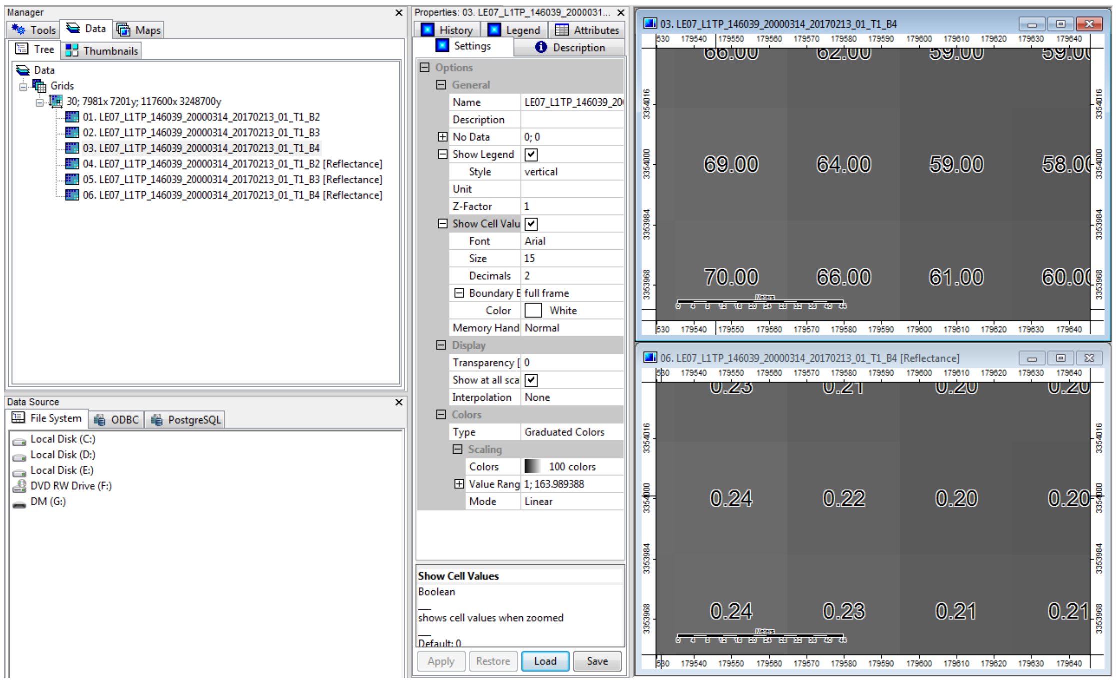




Enter the bands you wish to correct tool the will automatically create corrected bands.

Load the metadata.txt file that comes with Landsat scene downloads (This contains TOA correction details). Make sure you have the right Landsat sensor selected.

Open band 4 of the raw data and the reflectance data in different map windows, zoom in to pixel level and synchronize map extents. Check show cell values in the settings tab and compare. Notice that DN values of the original image is in 8 bit format and will range from 0 to 255, whereas cell values of the data will range from 0 to 1.

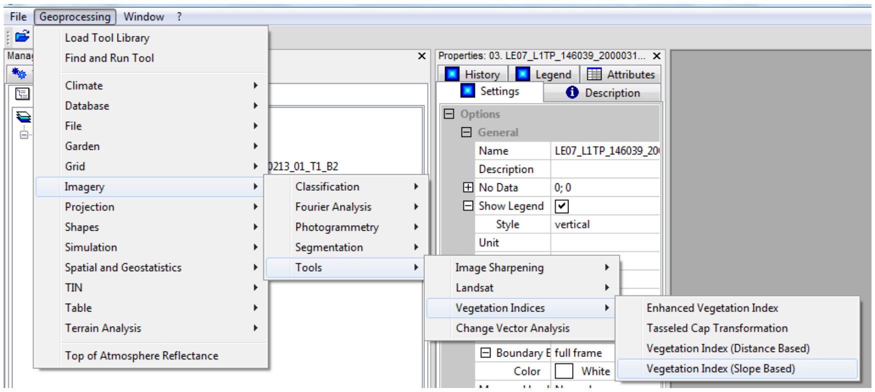


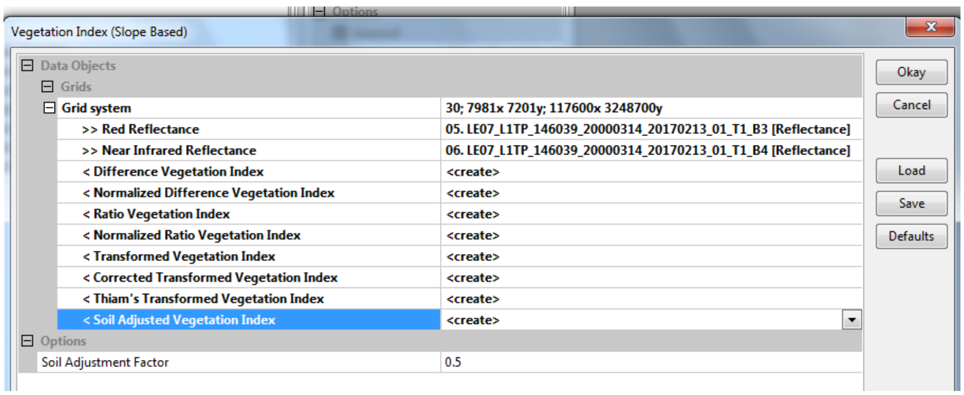
Calculating Vegetation Indices

A variety of algorithms have been developed by researchers in an attempt to extract the most information from the satellite image spectral bands. Many of these are vegetation indices used for monitoring and mapping vegetation vigour. SAGA allows the automated calculation of a number of these.

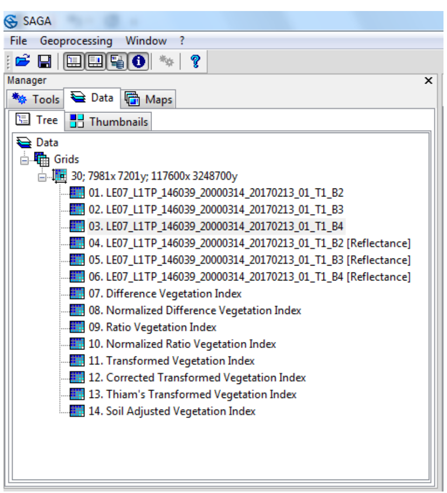
Geoprocessing>Imagery>Vegetation Indices

The example shown below is using the Vegetation Index (Slope Based). Simply enter the Red and Near Infrared bands (4 and 5 for Landsat 8) and select <create> for the index you would like to calculate.

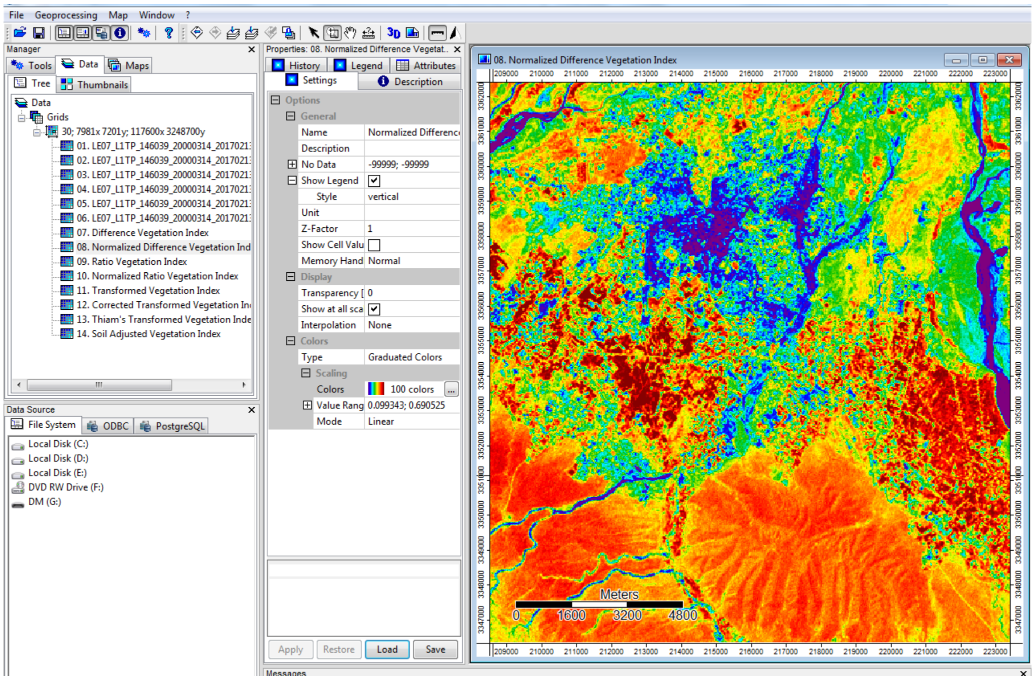




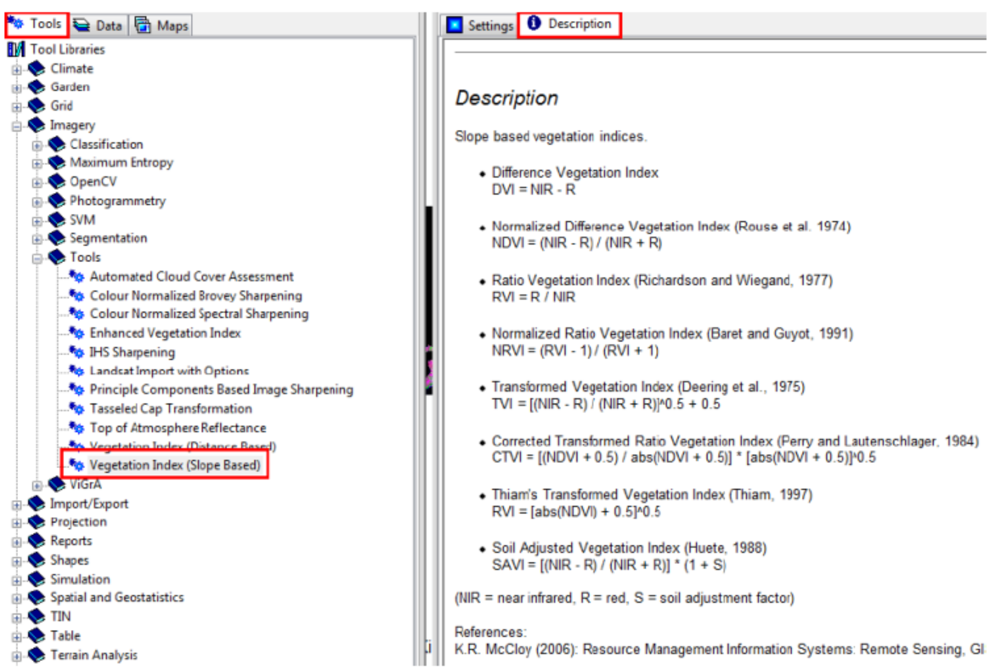
You will see all the new band combinations/indices in the data tab:



Displaying one of the vegetation indices as green as a rainbow display really highlights the distribution of actively growing (high photosynthetic activity) vegetation as shown in the image below. Red areas indicate higher NDVI values represented by greener areas which are mostly forest or agriculture land. Blue areas indicate lower NDVI values as represented by built-up areas and river bed etc.



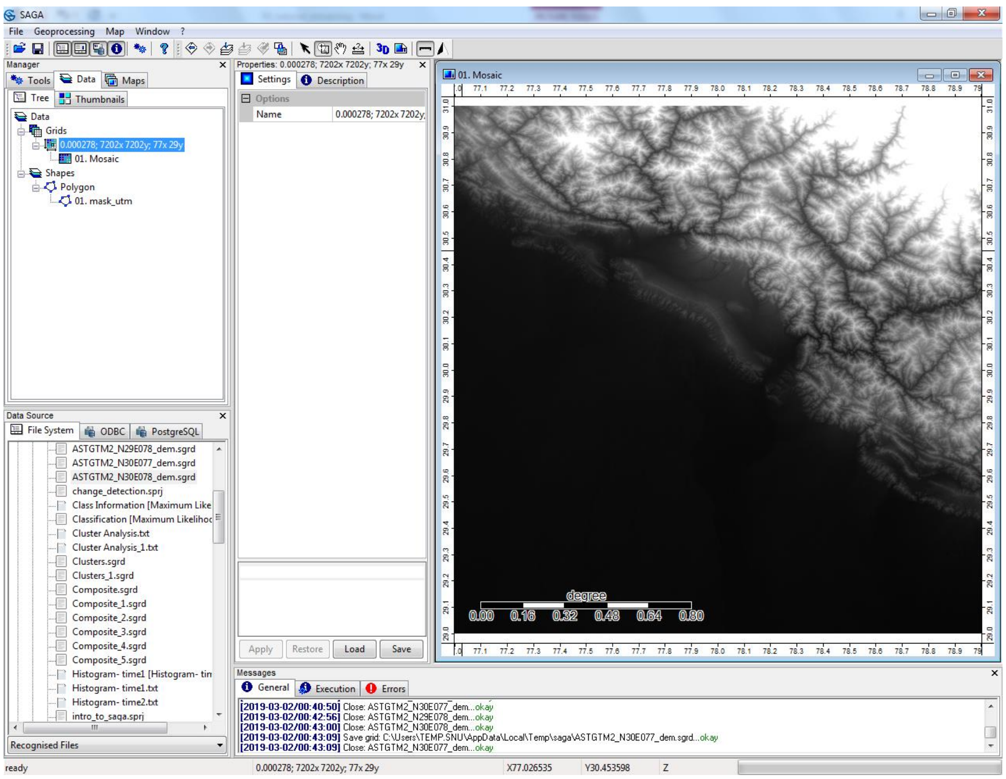
To find out the meaning of all the different vegetation indices and how they might be interpreted you can view further information if you select the vegetation index module in the Tools tab and select the description tab. As shown below it provides a description of the algorithms used to calculate each indices and references to more information.



Reprojecting toposheet or raster

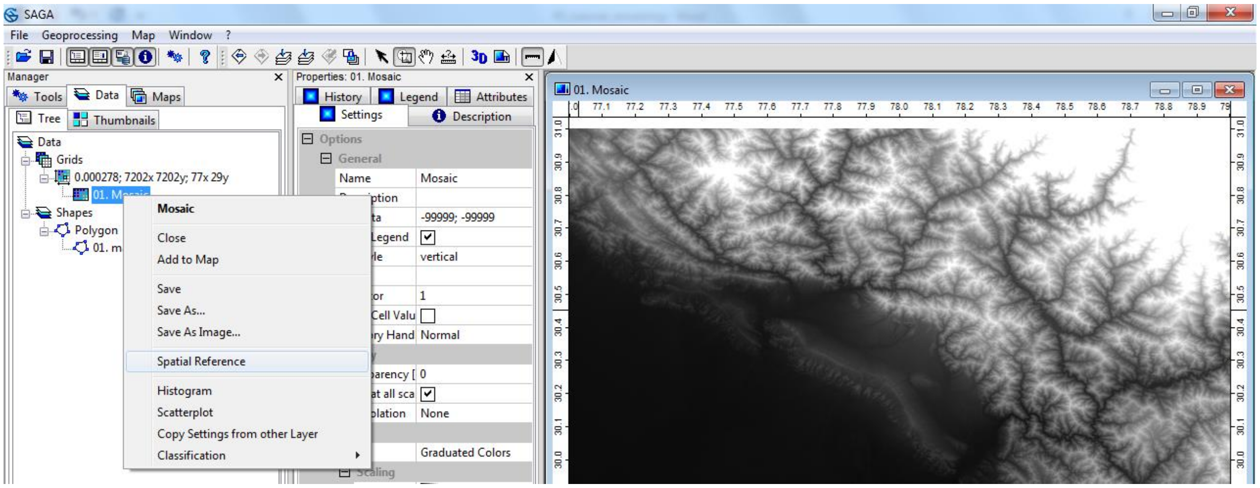
Load the DEM data. This has units in degree. It is in a geographic coordinate system (Lat/Long).
And the projection system is GCS WGS 84.

Load the shapefile data provided. This file is in a UTM (Universal Transverse Mercator) projection.

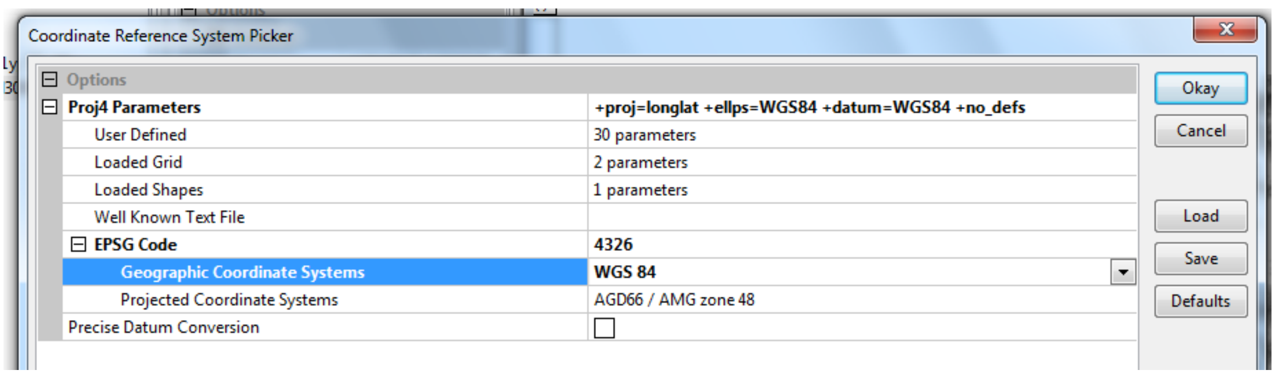


Reprojecting the ASTER DEM data to a UTM projection will also allow us to combine it with the UTM polygon file. To reproject first set the projection of the current data set.

Right click on the ASTER DEM grid layer and select spatial reference:

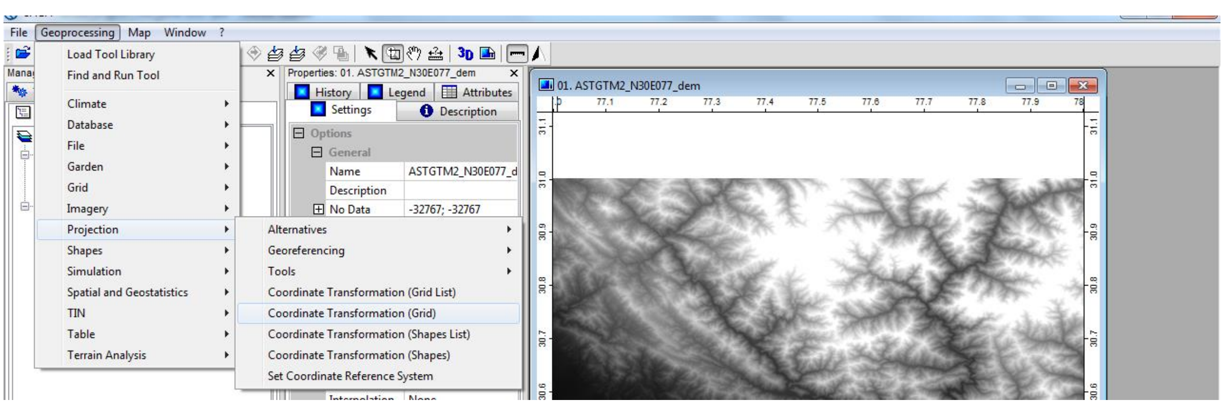


Set the spatial reference to the WGS 84 geographic coordinate system as shown below:

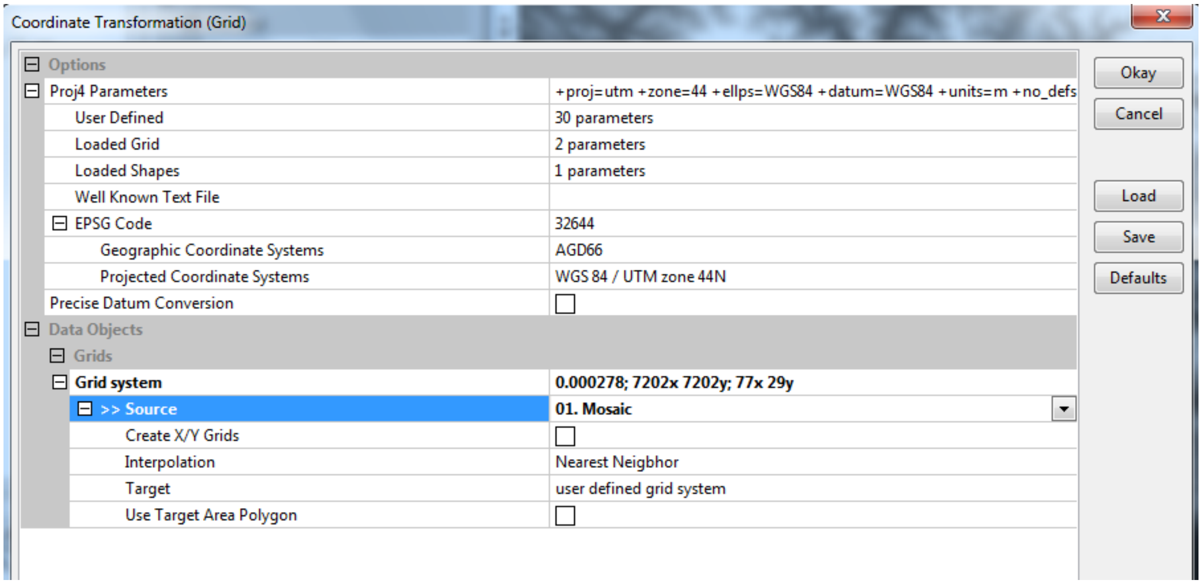


We can now re-project the elevation data into our UTM zone (44N).

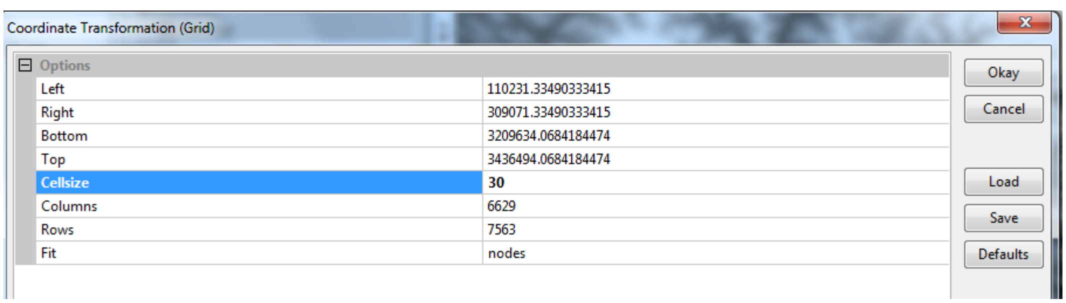
Geoprocessing > Projection > Coordinate transformation Grid

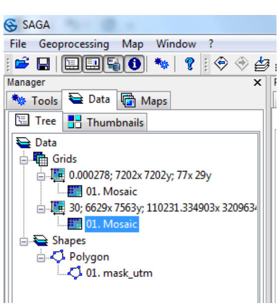


In the module dialogue window:
1. Enter the ASTER DEM grid to be projected
2. Set the resampling to "Nearest Neighbour"
3. Set the Projected Coordinate system to UTM Zone 44N.

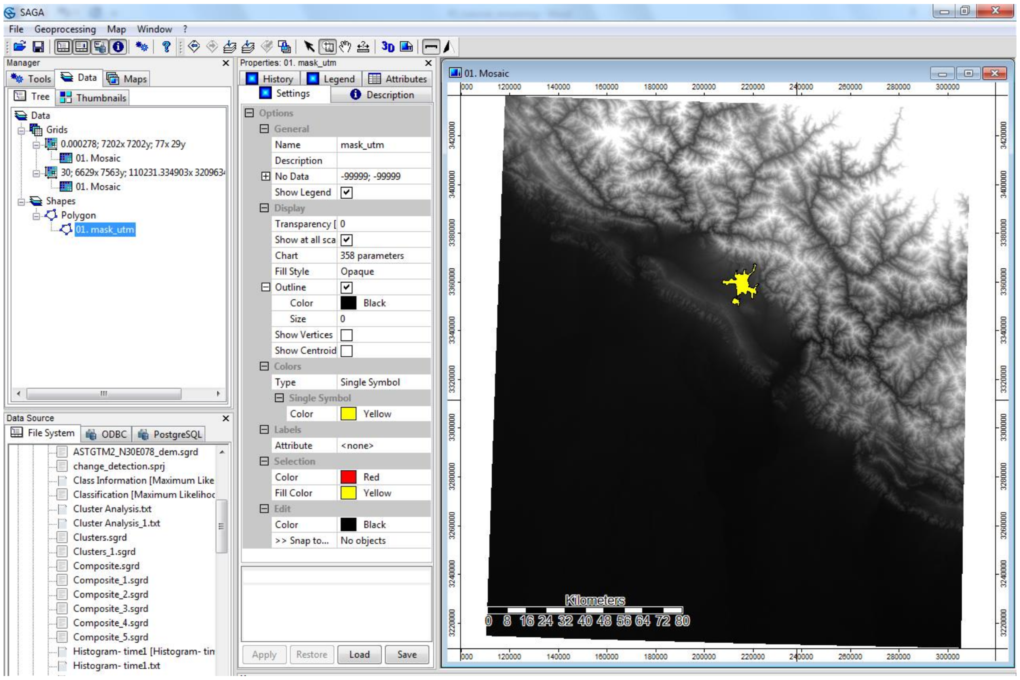


A new dialogue box will appear where you can set the output cell size. For standard ASTER DEM data this should be 30 metres.





You should now be able to display the mask boundary vector data over the top of the new reprojected elevation file.



You will be able to notice a slight tilt in the DEM data due to projection transformation and now the scale is in kilometers and not degrees.

Add the mask shapefile to the same map window.

To view the grid data under a polygon file set the fill style to '*Transparent*' in the display settings tab.

Vector layers can also be re-projected following similar steps and using Geoprocessing> Projection>Coordinate Transformation (Shapes).

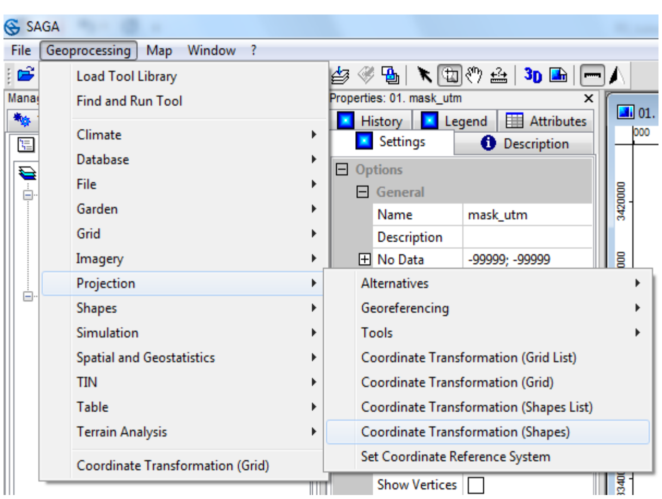
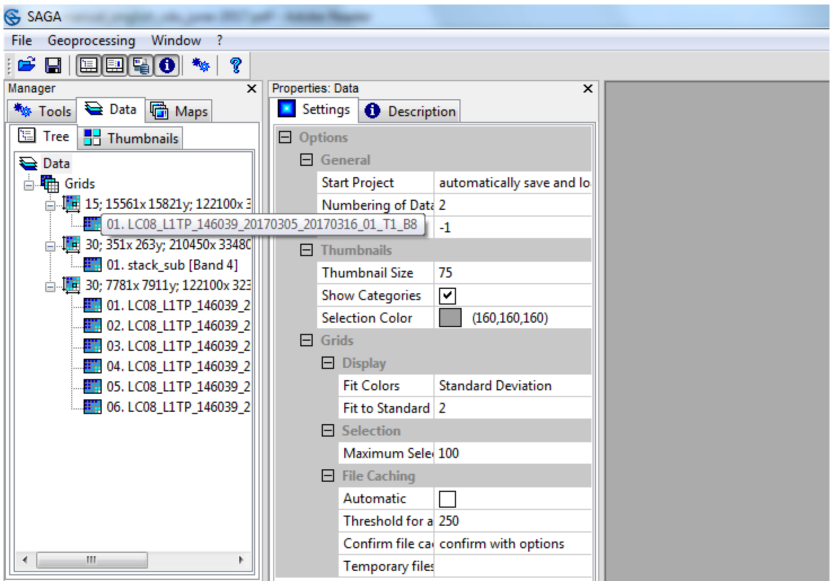
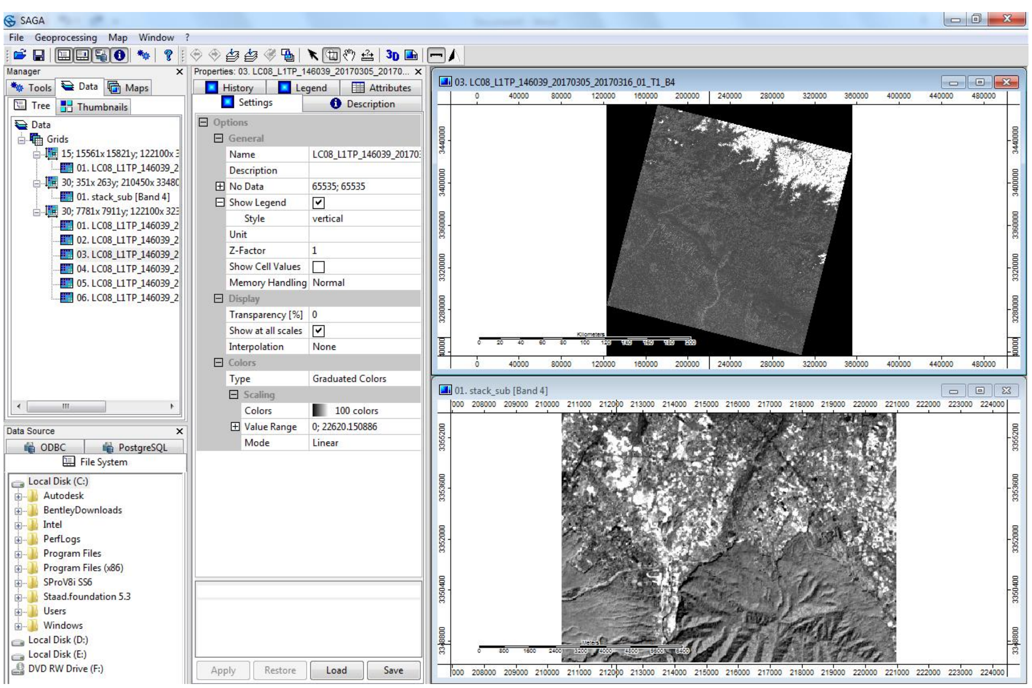


Image subset using a raster Grid

Load both the datasets as well as panchromatic band of L7 data as learnt in earlier tutorials.

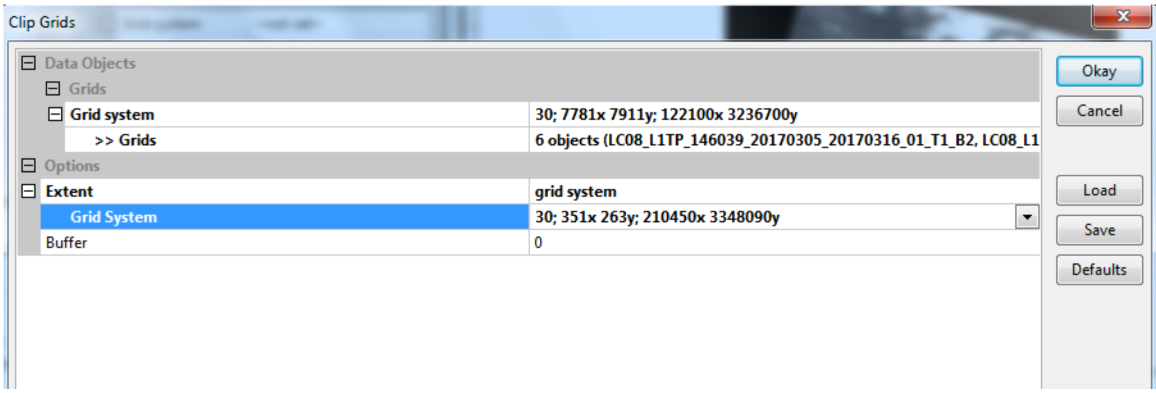


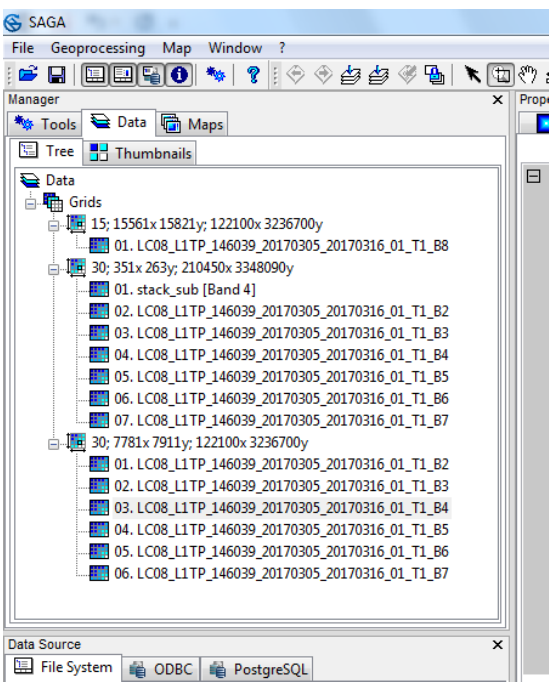
Display band 4 of stack_sub and band 4 of landsat 7 data using Add to Map option and tile horizontally from window tab



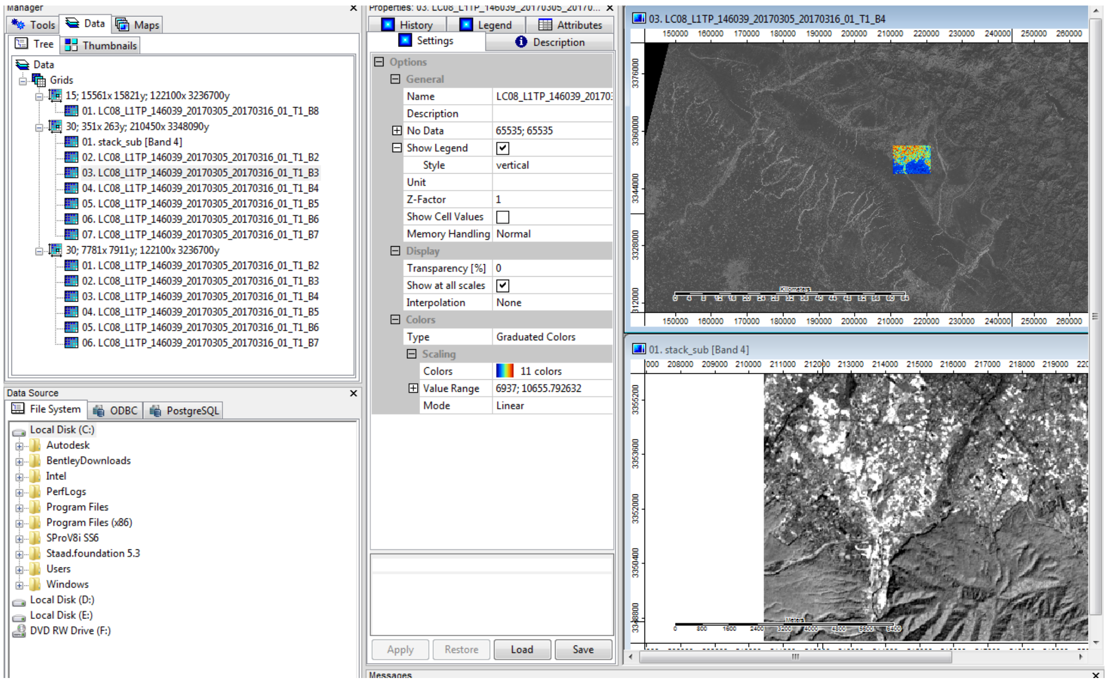
We will clip the Landsat 7 data same as the extent of stack_sub.
Go to Tools>Grid-Tools>clip grids

And set the values as given below



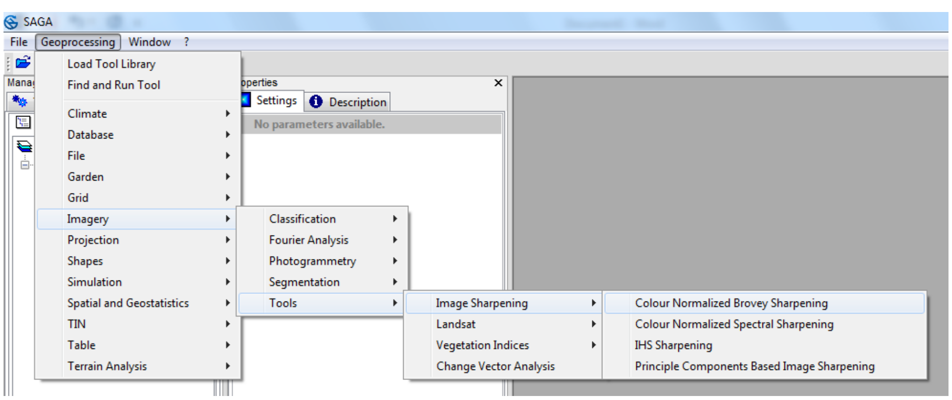


Add band 4 of the new clipped raster to the same window as landsat 8 data. You can see the subset added to its location in the original data.

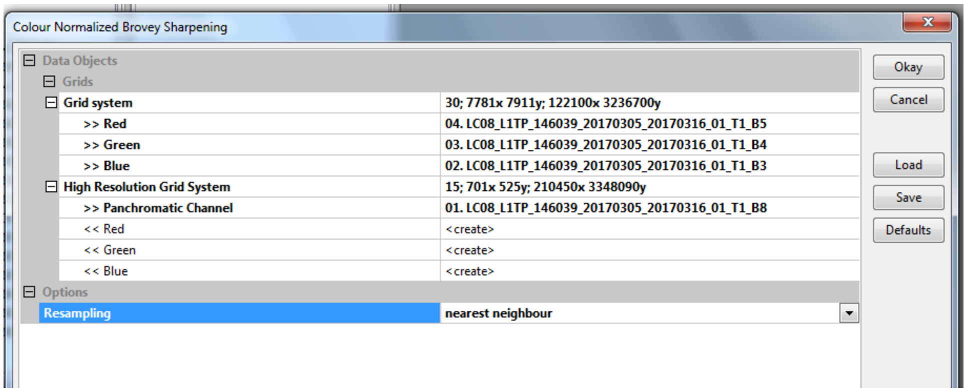


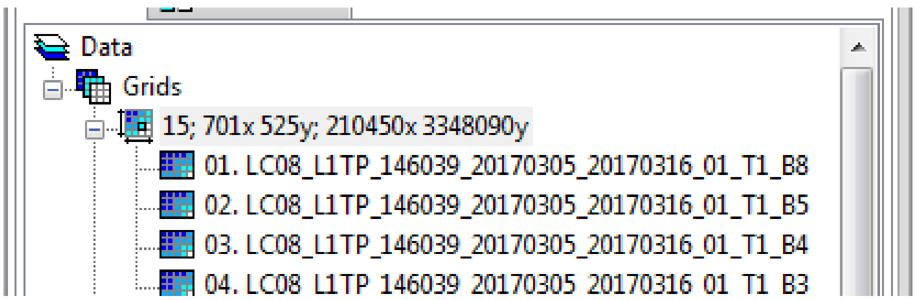
You can change the symbology to greyscale as described in previous tutorials. Similarly, clip panchromatic band (15m) also.

Image Sharpening

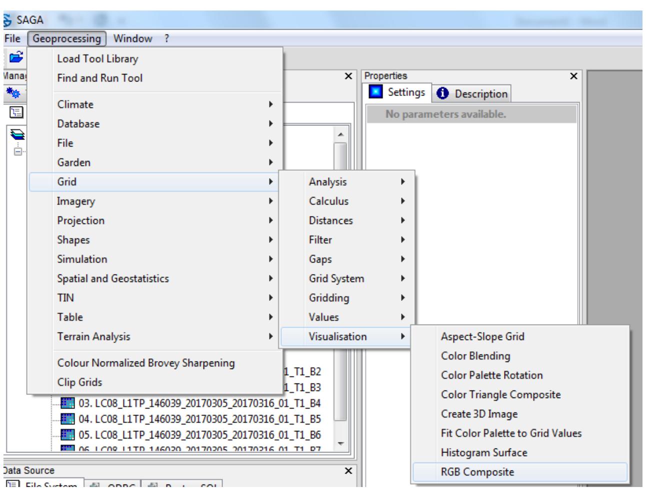


Enter the 30-metre bands you wish to sharpen and the band 8 grid for the high-resolution band.

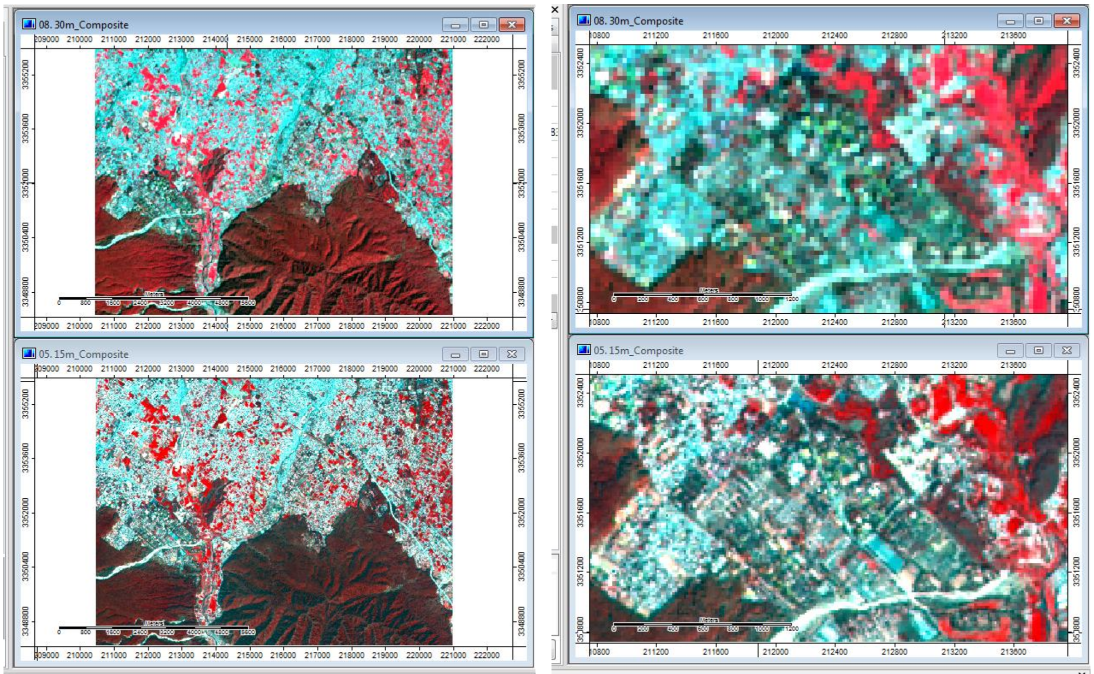




Now display the new band 543 grid (15m) as well as 30m band 543 grid as a band composite image to compare the resolution difference.



Zoom to a closer level and examine the changes.



15m composite has enhanced visualization for smaller features like settlements which were not separable in 30m composite.

Try other image sharpening algorithms also other this procedures.

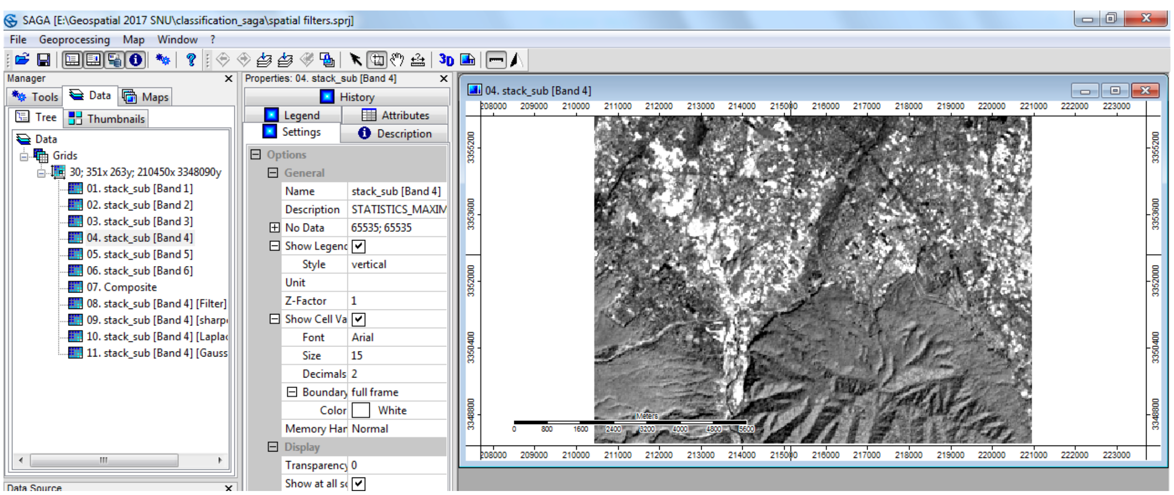
FILTERING AND ENHANCEMENT

Images come in varying levels of quality and information. Using filters, we can remove the noise from an image, making it fit for analysis and interpretation. Sometimes, even having high quality images may not be enough, to glean more specific information it is necessary to process it with various algorithms. Generally, Kernel filters are used to accomplish these tasks. A kernel filter uses a moving window that processes each pixel value taking into account the values of the neighboring pixels. They may be used to highlight/suppress specific information in the image.

In this tutorial we will learn to use different filters to perform some basic enhancements on 'subset of a Landsat 8 image and 'Land use and Land Cover Classification' images.

1. Start SAGA GIS and open the image by clicking the ***'Load'*** button and navigating to the folder containing the tutorial data to open the file named '***stack_sub***'.

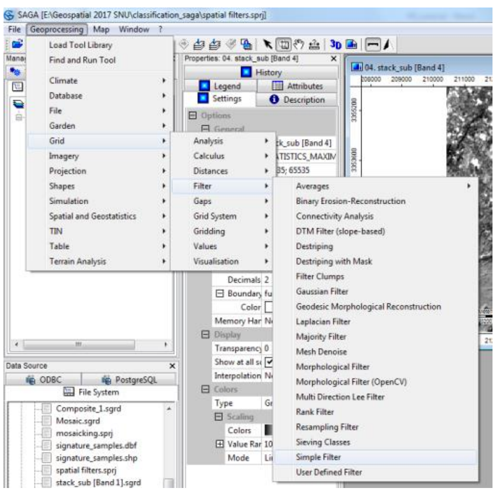
2. The image is loaded in the tab list. Double click on it to open it.

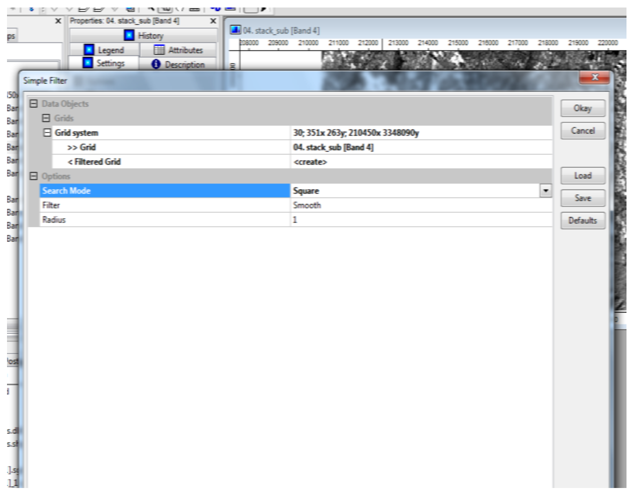


Low-Pass (Smoothing) Filter: This filter is the most basic filter used for smoothing an image. It blurs the small features by taking the average of the center pixel and the neighboring pixels. The new value of the pixel depends not just on the original value but on the neighboring pixels as well. Thus, by suppressing the starkness of the central pixel it blends in with the rest of the pixel neighbors. It is called a *'Low Pass'* filter because it passes the features of low spatial frequency while removing the high frequency features.

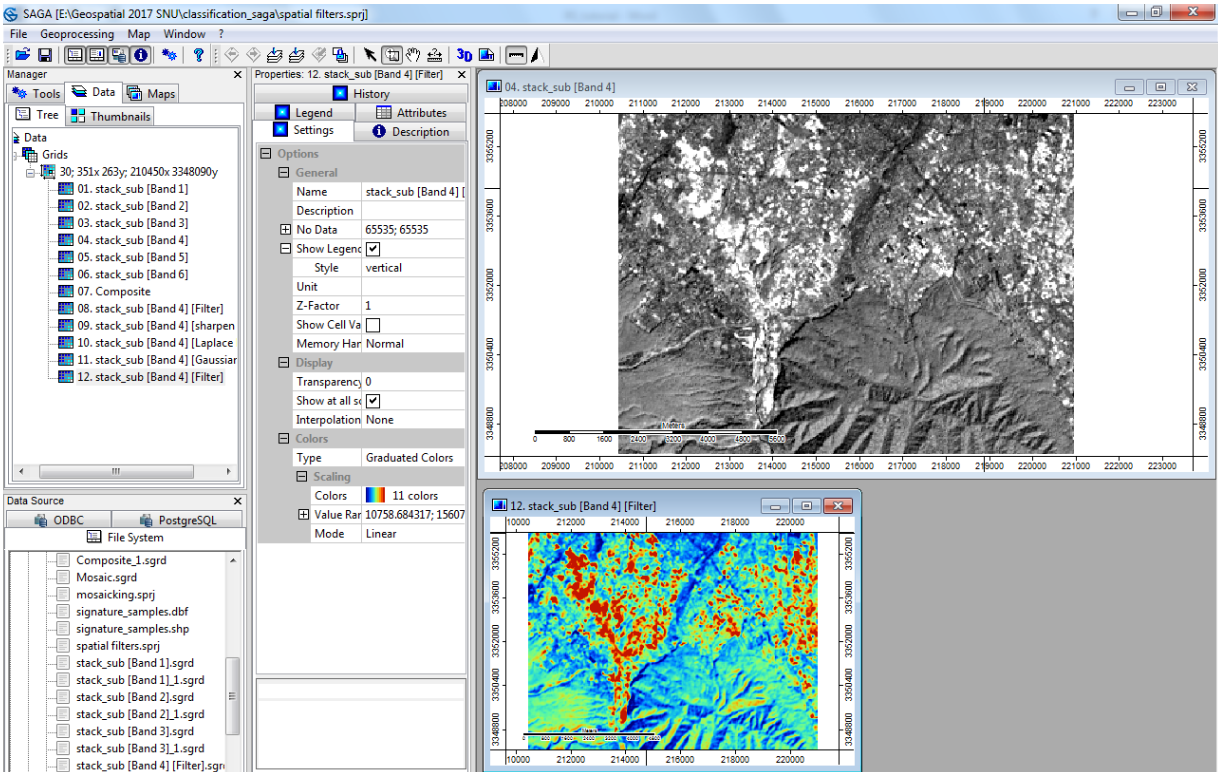
Open simple kernel filter via, *Menu → Geoprocessing → Grid → Filter → Simple Filter*. Set the '*Grid System*' and '*>>Grid*' to the current image (i.e., *stack_sub*) and Change the '*<Filtered*' *Grid* output to ***[create]***. If this is '*[not set]*' then the output would overwrite the original image. The options are explained below:

Search Mode: This is the shape of the kernel window. The default is Circle. Change it to ***'Square'***.
Filter: This tells us which type of filter we are applying to the image. Since we are doing a smoothing of the image, we will use the ***'Smooth'*** option.
Radius: The radius describes the size of the kernel window. The value **1** represents a kernel size of 3x3 pixels. If the value 2 represents 5x5 and so on. For now, we will use the value **1**. Click '***Okay***'.

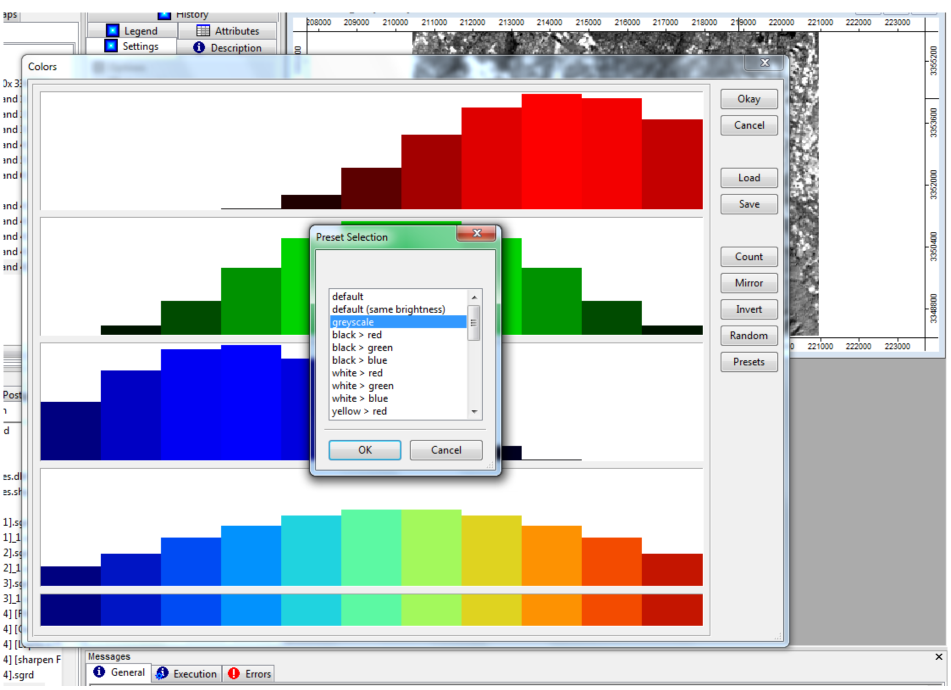


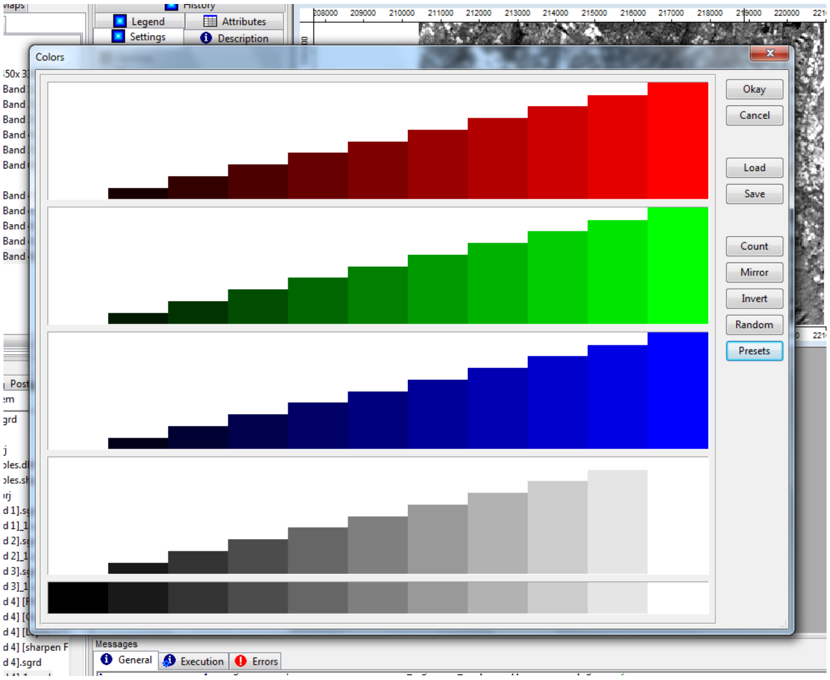


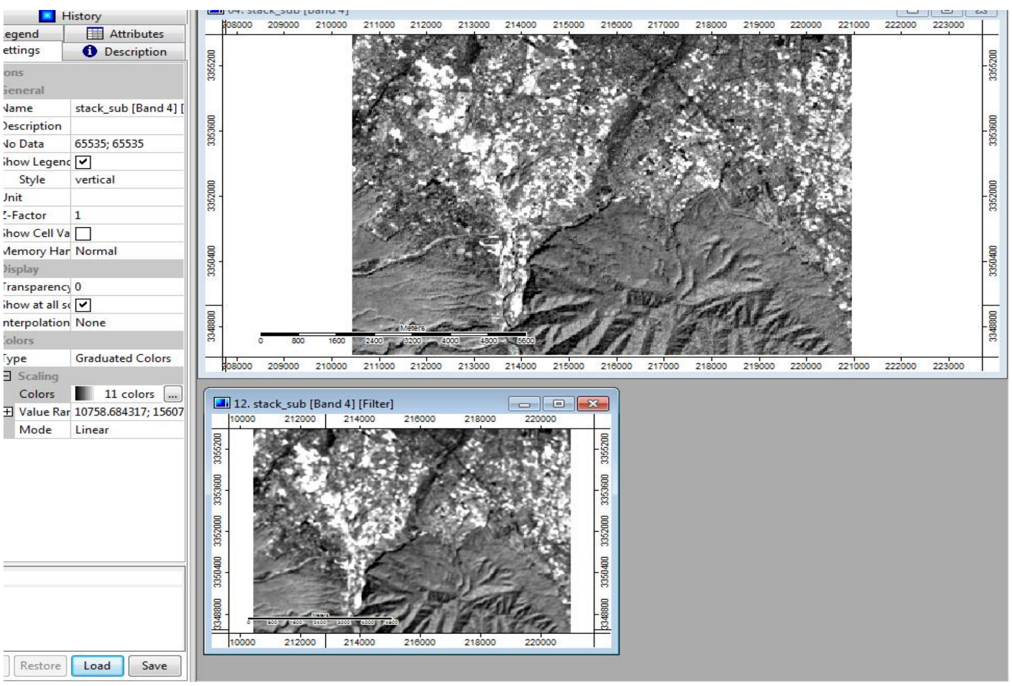
Open the filtered image in a new map window by double-clicking on it in the list under '*Data*' tab. In the popup window select '***New***' and click '***OK***'.

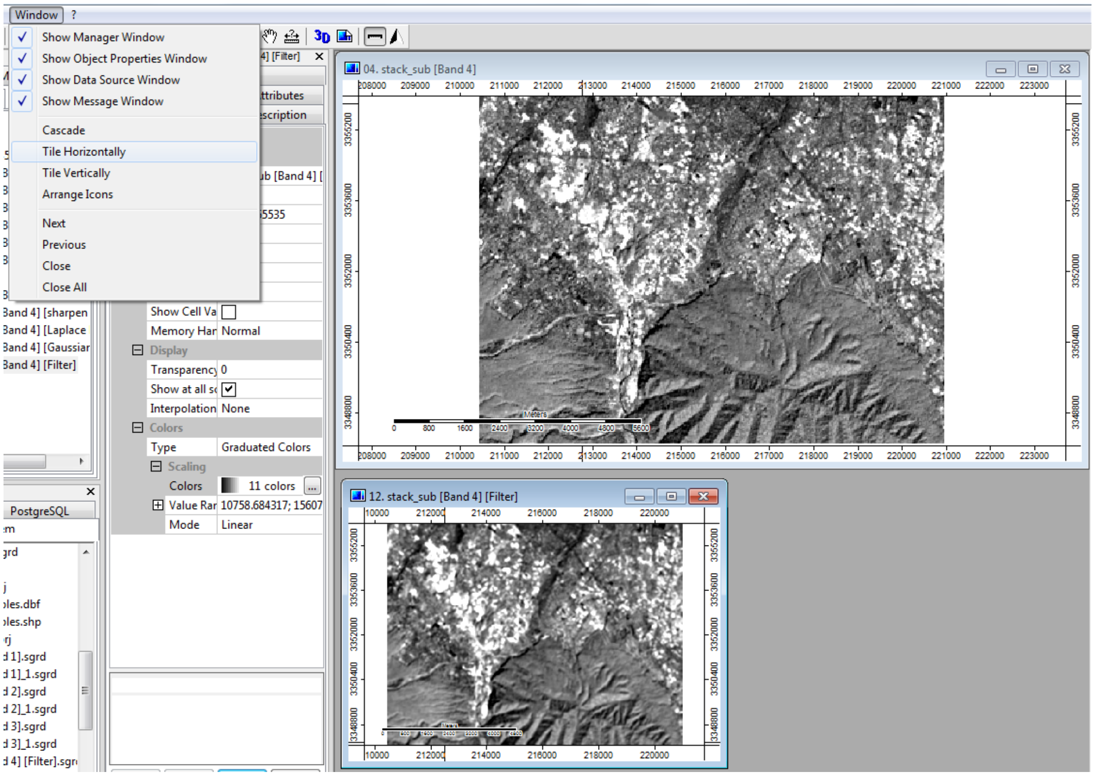


Change the color symbology of the filtered image from color→preset→greyscale→Okay→Apply

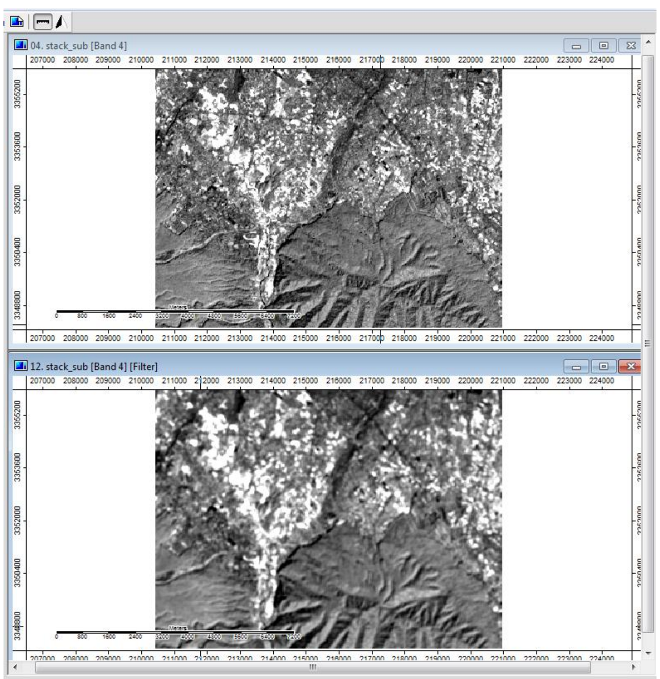



Legend
Attributes
Settings
Description
Colors
Okay
Cancel
Load
Save
Count
Mirror
Invert
Random
Presets
Messages
General
Execution
Errors


History
Attributes
Description
Name
stack_sub [Band 4] [
No Data
65535; 65535
Style
vertical
Z-Factor
1
Memory Har
Normal
Transparency
0
Interpolation
None
Type
Graduated Colors
Scaling
Colors
11 colors
Value Rar
10758.684317; 15607
Mode
Linear
Restore
Load
Save
12. stack_sub [Band 4] [Filter]

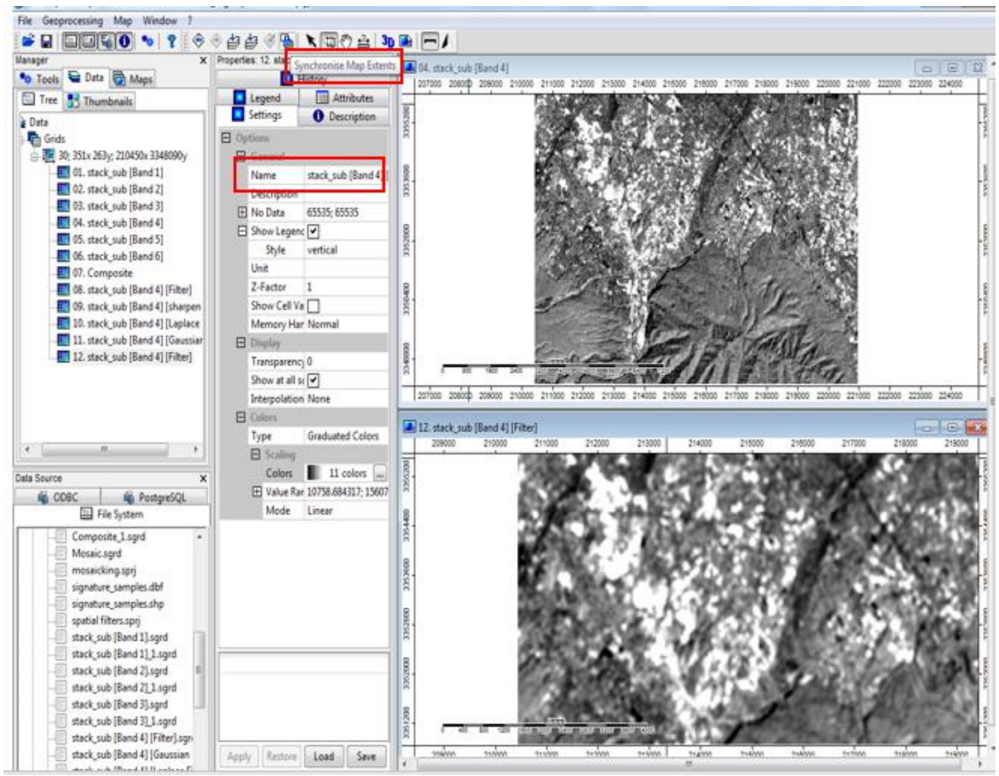


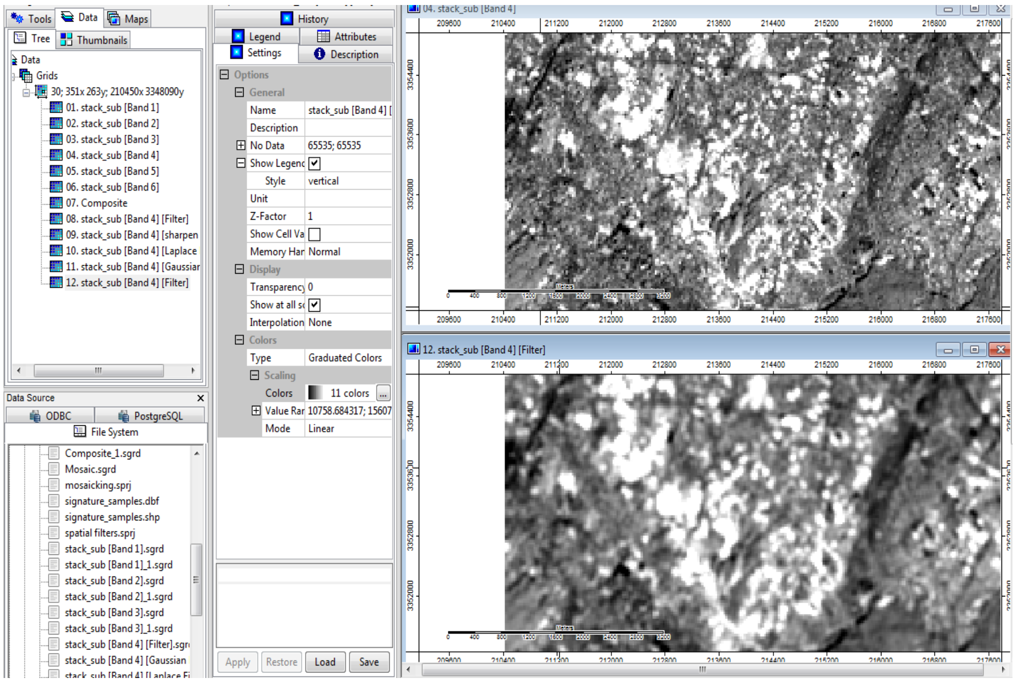
Tile the viewers from Windows→Tile Horizontally

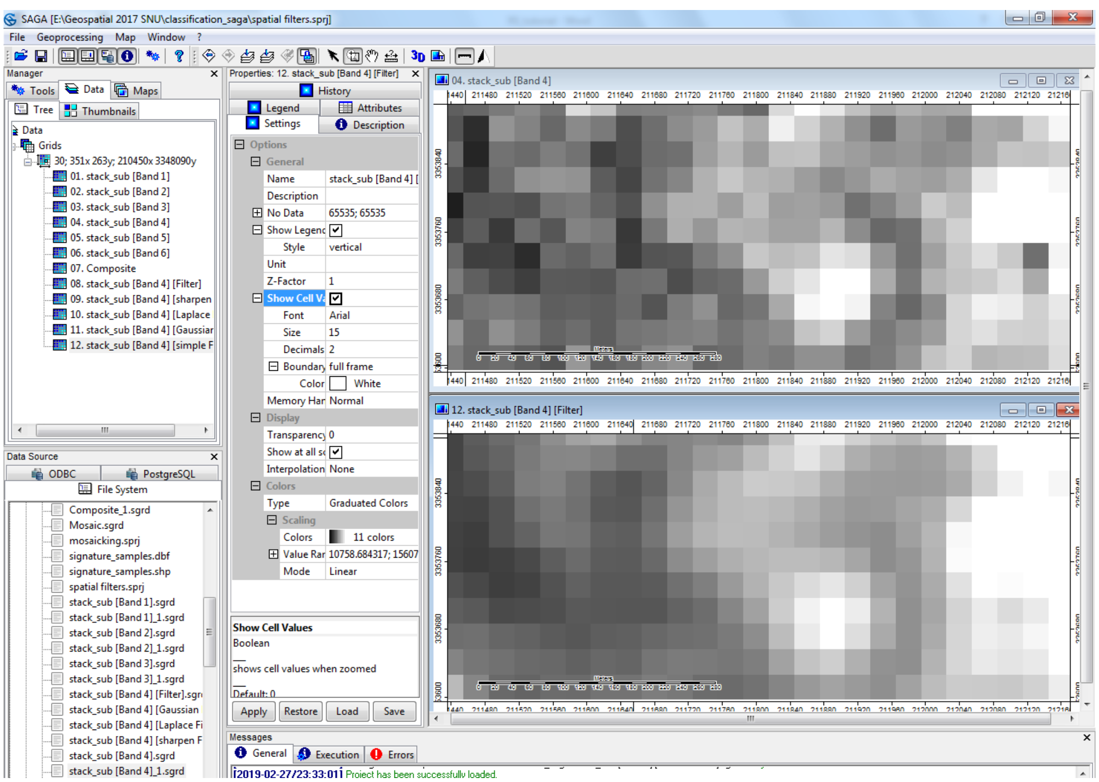


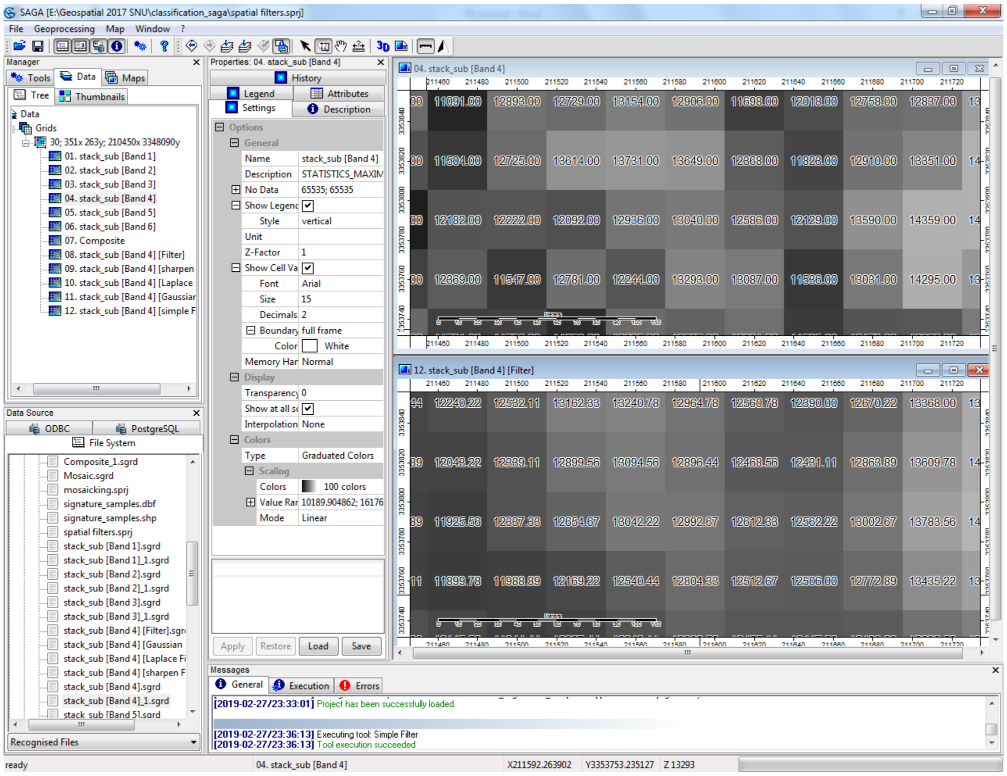
Select the first map window and synchronize their extents *via, Menu → Map →Synchronize Map Extents).* Click the ***'Action Tool'*** button, ***'zoom in'*** to Individual pixel level as shown below, and *select a few* pixels. From the Settings tab, check Show Cell Values and click '***Apply***'.

You can change the name of the output image in the '*Name*' section, press '***Tab***' from the key board and click '***Apply***'.




Tools
Data
Maps
Tree
Thumbnails
Grids
30; 351x 263y; 210450x 3348090y
01. stack_sub [Band 1]
02. stack_sub [Band 2]
03. stack_sub [Band 3]
04. stack_sub [Band 4]
05. stack_sub [Band 5]
06. stack_sub [Band 6]
07. Composite
08. stack_sub [Band 4] [Filter]
12. stack_sub [Band 4] [Filter]
History
Legend
Attributes
Settings
Description
Options
General
Name
No Data
65535; 65535
Display
Colors
Graduated Colors
11 colors
Linear
Apply
Restore
Load
Save
04. stack_sub [Band 4]
12. stack_sub [Band 4] [Filter]

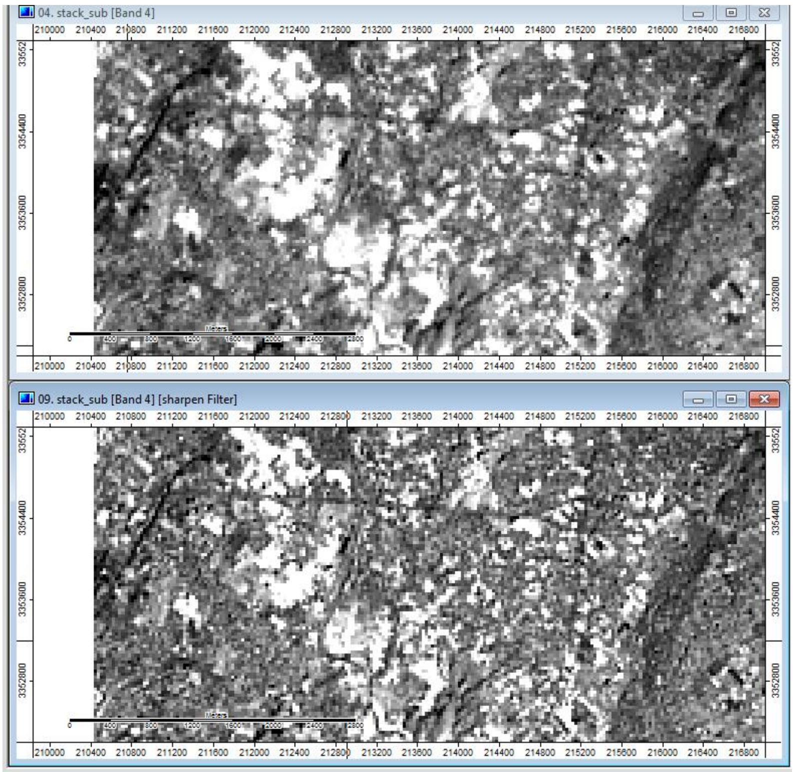

SAGA [E:\Geospatial 2017 SNU\classification_saga\spatial filters.sprj]
File
Geoprocessing
Map
Window
Properties: 12. stack_sub [Band 4] [Filter]
Show Cell Values
Boolean
shows cell values when zoomed
Font
Arial
Size
15
Decimals
2
04. stack_sub [Band 4]
12. stack_sub [Band 4] [Filter]
Messages
General
Execution
Errors
[2019-02-27/23:33:01] Project has been successfully loaded.



As we see above, the central pixel on the left gets smoothed to more closely resemble its neighbors.

High-Pass (Sharpening) Filter: A sharpened image is one in which the smaller features are made more prominent. They appear sharper when each pixel can be differentiated from its neighbouring pixels. To do this, we must heighten the difference between a pixel and its surroundings. The High-Pass filters often treated as *Edge detection or Directional* filters.

Go back to the Simple Filter module and change the *'Filter'* option to *'**Sharpen**'*. Change the output *'Filtered Grid'* to *'**[create]**'*. Click *'**Okay**'* (Refer *step* 4). Open the image in a new window and set its color scheme to Greyscale.

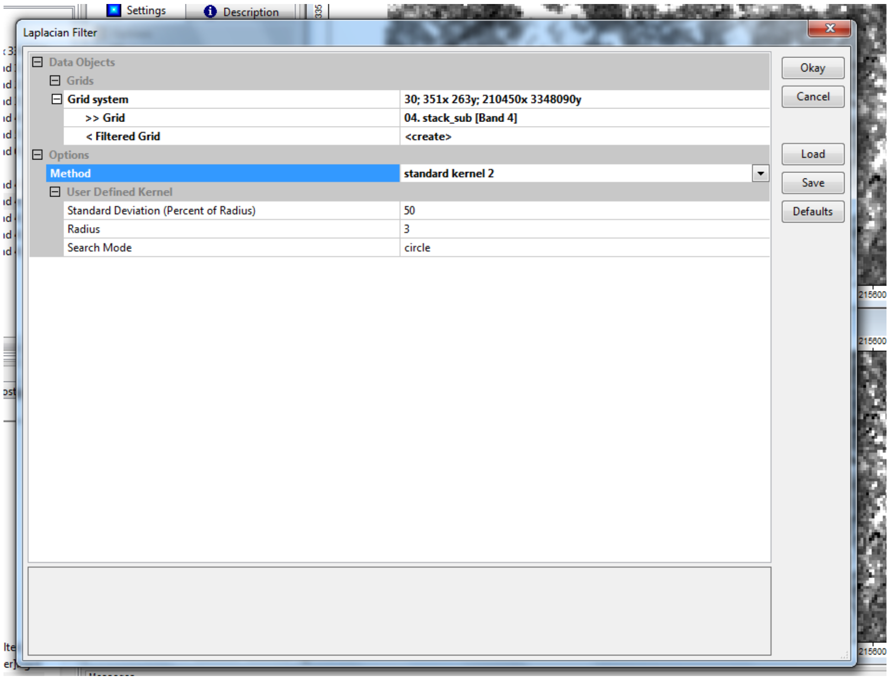


The filtered image (2nd image) has more sharp edges than the raw image.

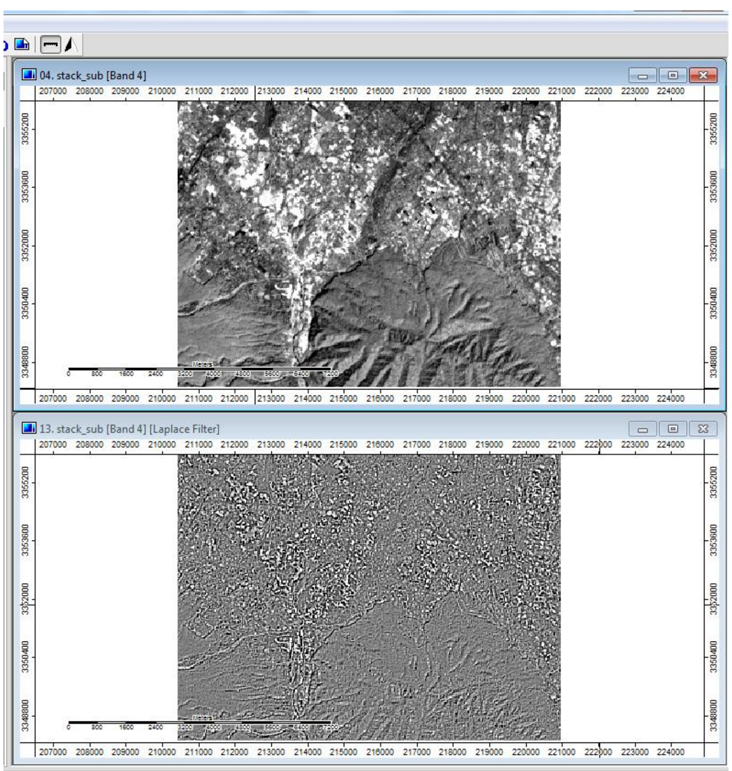
Edge Detection using the Laplacian-of-Gaussian filter combination: This combination of the Laplacian-on-Gaussian filters is used for sharpening images while preventing the amplification of noise. A Laplacian filter on its own would amplify the noise in an image.

However, if we preprocess it with a Gaussian filter, the noisy pixels get smoothed out. This reduces the chances of noise amplification.

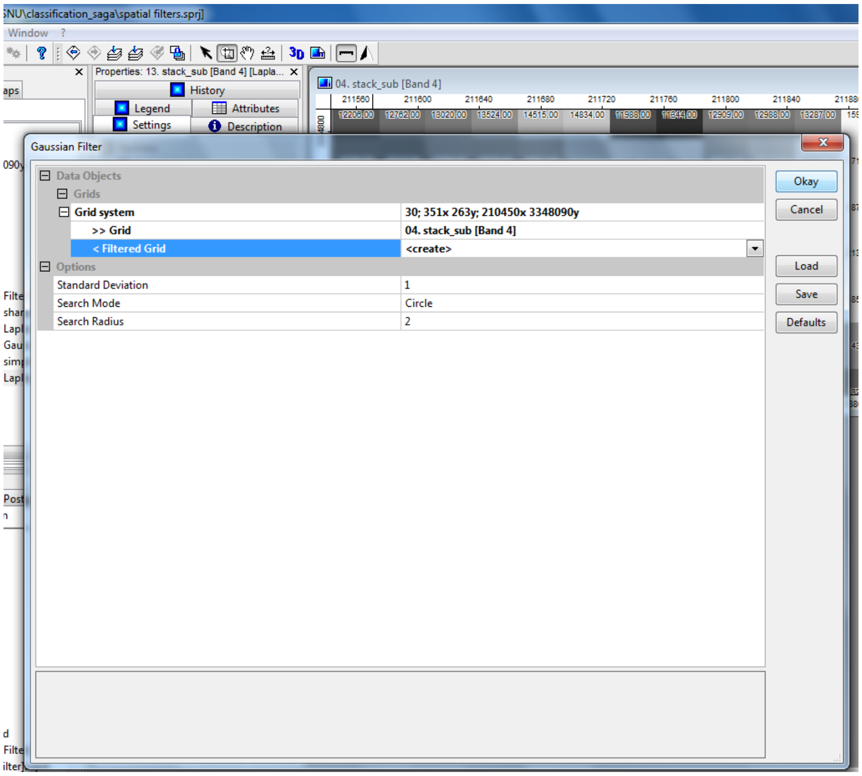
Open the Laplacian Filter module via *Geoprocessing → Grid → Filter → Laplacian Filter.* Set the options as given below. Ignore the options under *'User Defined Kernel'*, since we are using the ***'Standard Kernel 2'*** and click '***Okay***'.

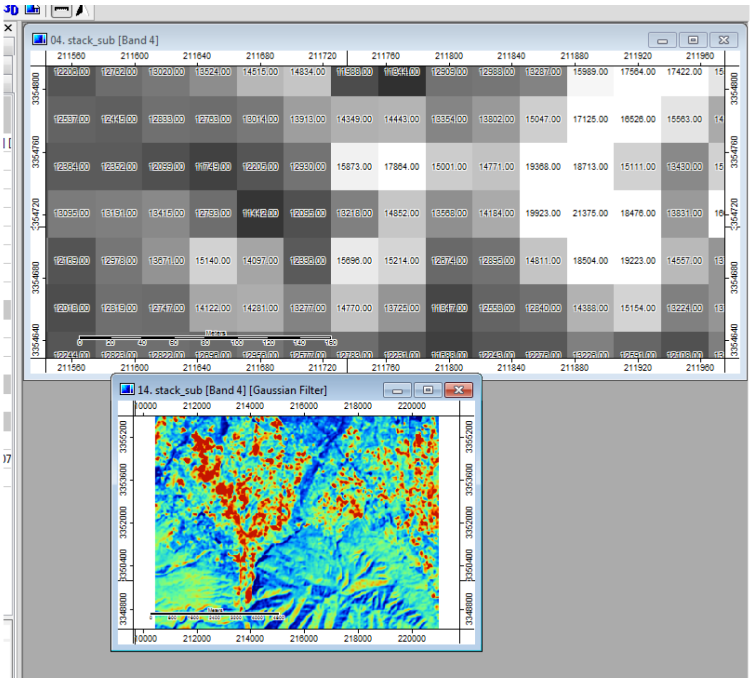


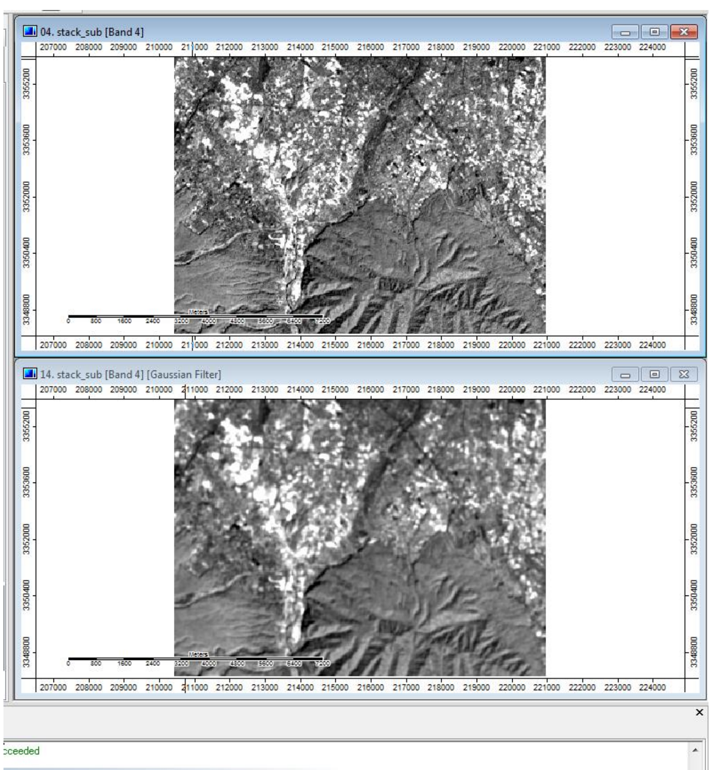
This will create an edge filter which highlights all the edges in the image. An edge is signified by an abrupt and sudden change in pixel values. This allows us to identify the boundary of features easily.

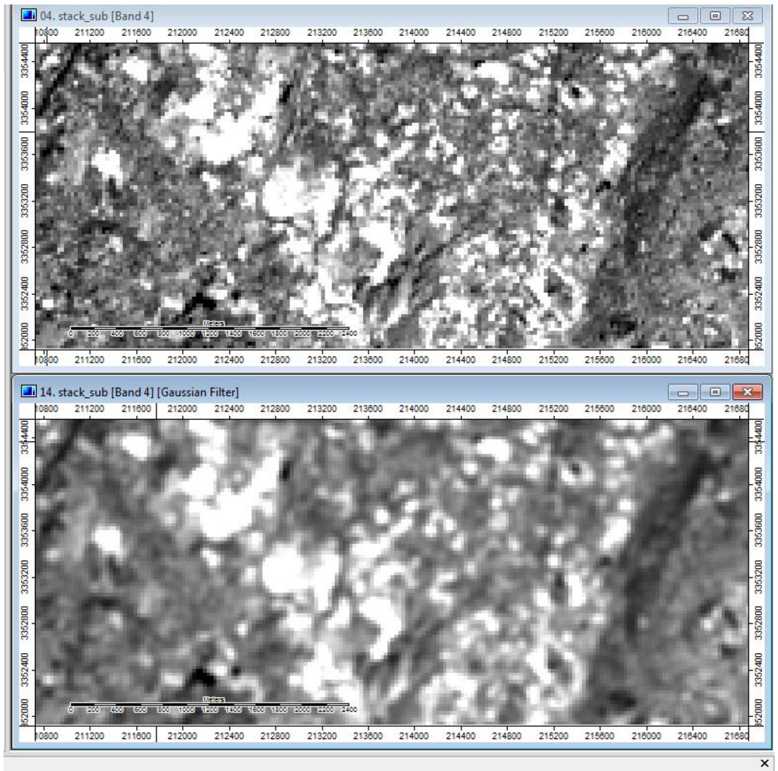


To reduce the amplification of noise we will first pass a Gaussian filter over the image. Open the module via *Geoprocessing → Grid → Filter → Gaussian Filter*. In the filter window, set the options as shown below. For now we will use the default options. Set the output '< *Filtered Grid*' to ***'[create]'*** and click '***Okay***'. Change the colour ramp to original image. *And tile horizontally*

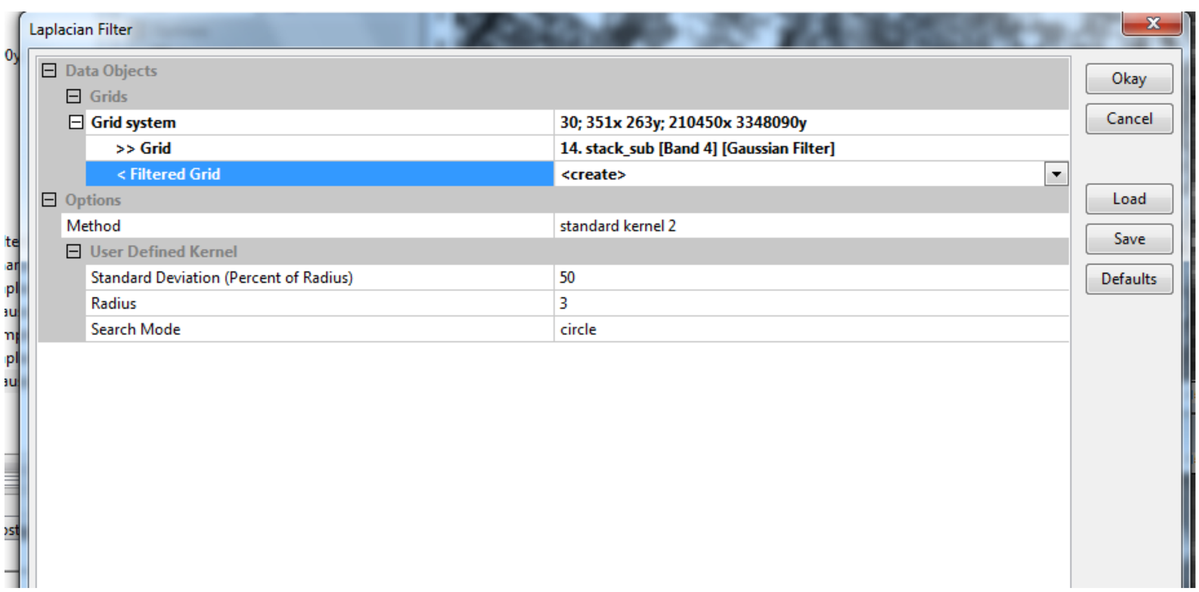


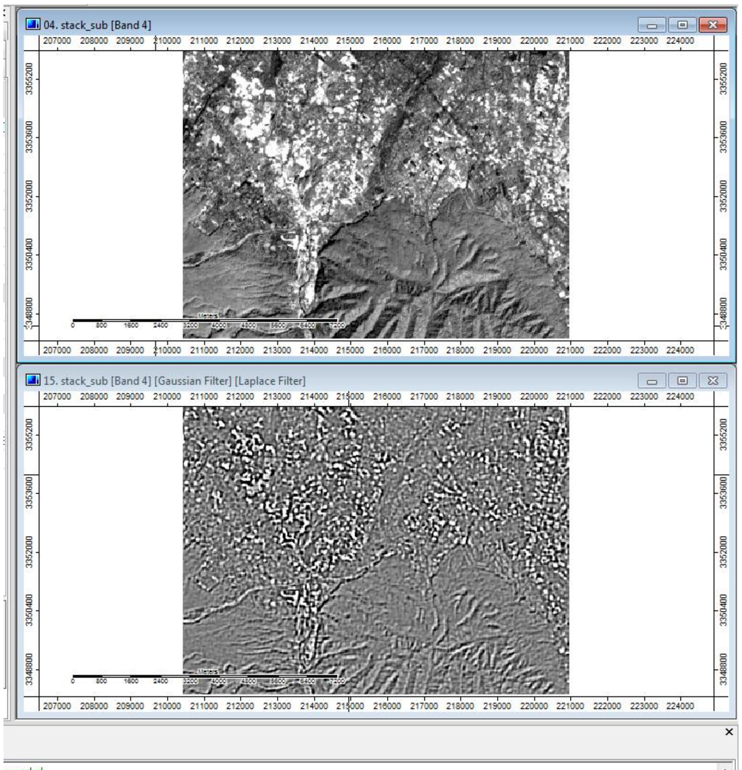

04. stack_sub [Band 4]
14. stack_sub [Band 4] [Gaussian Filter]

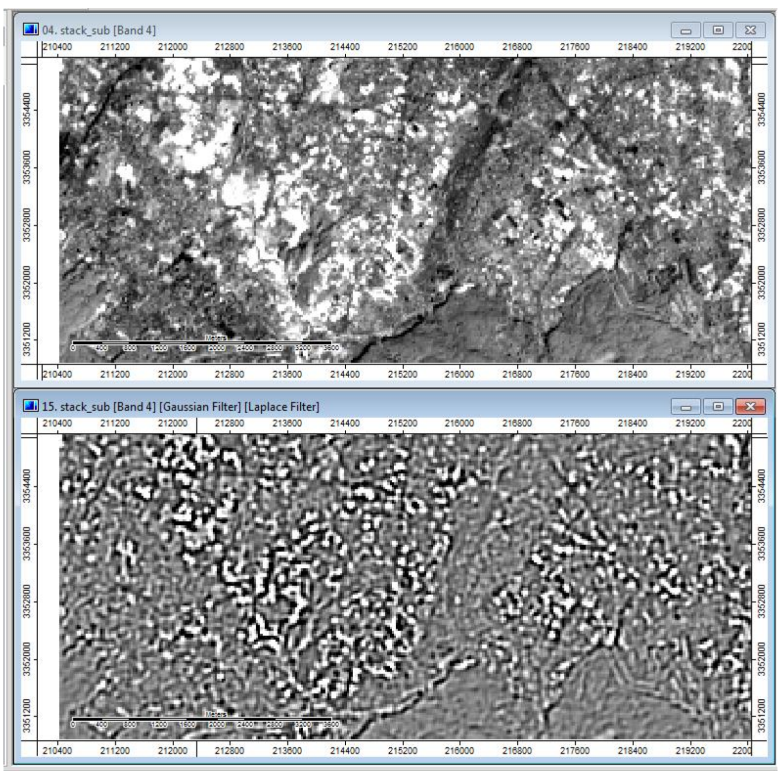

04. stack_sub [Band 4]
14. stack_sub [Band 4] [Gaussian Filter]



Now, pass a Laplacian filter on this Gaussian smoothed image (output of *step 13*) referring *step 10* and below figure.




04. stack_sub [Band 4]
207000 208000 209000 210000 211000 212000 213000 214000 215000 216000 217000 218000 219000 220000 221000 222000 223000 224000
3355200 3353600 3352000 3350400 3348800
15. stack_sub [Band 4] [Gaussian Filter] [Laplace Filter]
207000 208000 209000 210000 211000 212000 213000 214000 215000 216000 217000 218000 219000 220000 221000 222000 223000 224000
3355200 3353600 3352000 3350400 3348800


04. stack_sub [Band 4]
210400 211200 212000 212800 213600 214400 215200 216000 216800 217600 218400 219200
3354400 3353600 3352800 3352000 3351200
15. stack_sub [Band 4] [Gaussian Filter] [Laplace Filter]
210400 211200 212000 212800 213600 214400 215200 216000 216800 217600 218400 219200
3354400 3353600 3352800 3352000 3351200

MOSAICKING

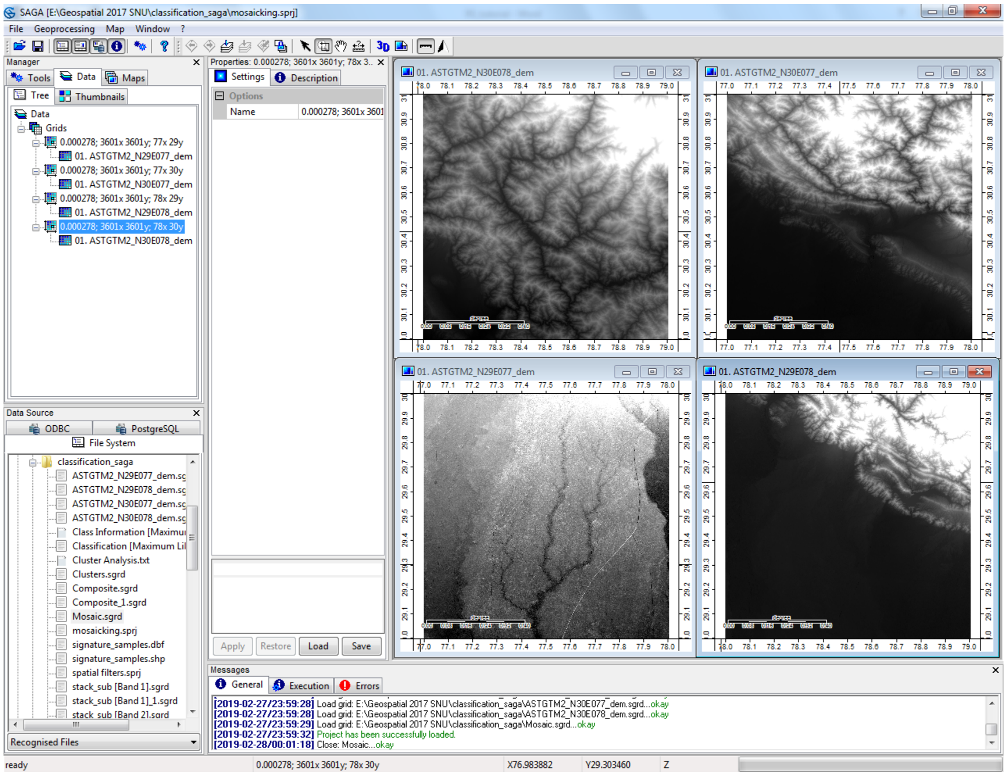
Introduction

Satellite imageries come in varying swath widths, depending on their source of acquisition. For example, the LISS-3 imagery is approximately 140 Km swath width while the Landsat TM imagery covers 185 Km, and SPOT imagery is just 60 Km swath width. These images cover large swathes of land but in most of the cases the Area of Interest (AOI) is not covered by a single satellite image. We need to assemble the satellite images which cover the individual parts of AOI to form a single composite. This composition process is known as 'Mosaicking', it requires very accurate radiometric and geometric corrections to the constituent imageries (Rees, 1999). Sometimes, for management or other reasons, only a part of the entire image needs to be displayed or processed to convey the information or to represent the whole. Therefore, it becomes necessary to extract the area of interest from the images/ mosaics, and this extraction process is known as 'Subsetting'. In some software packages it also called as Extract, Clip or Cut.

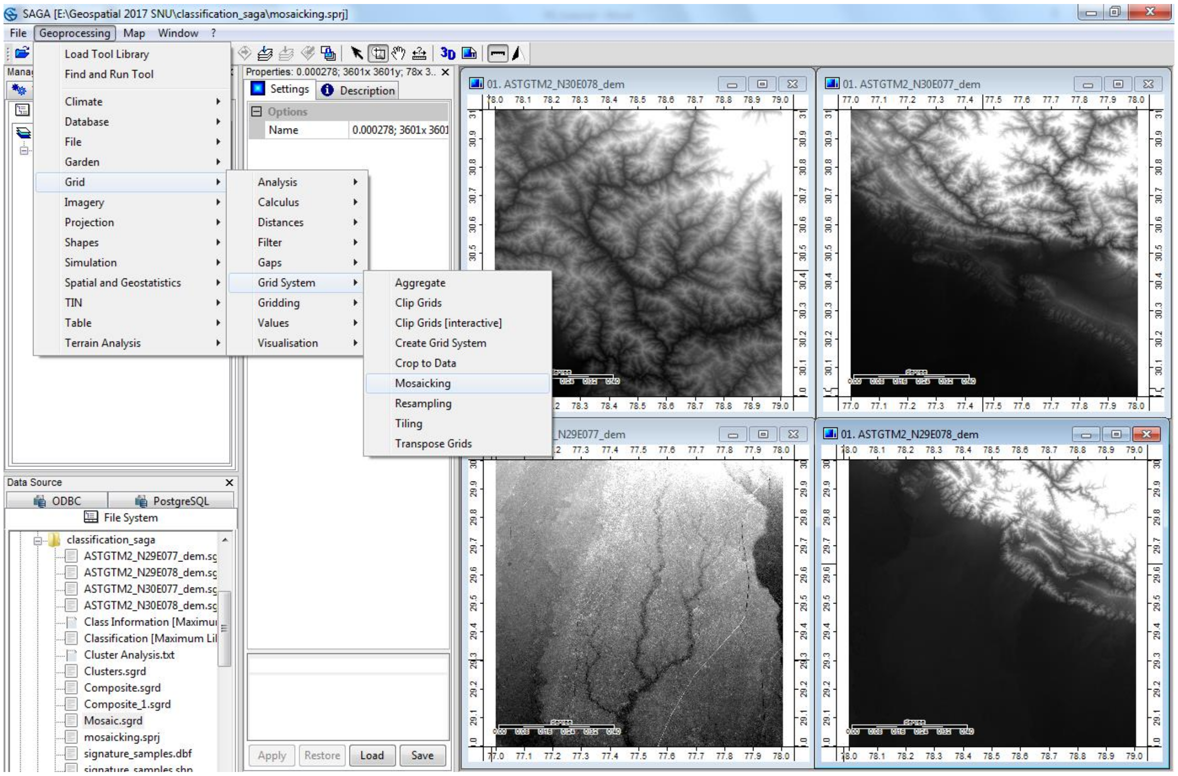
In this tutorial, you are supplied with four images of ASTER DEM (30m spatial resolution) of a part of Uttarakhand. The objective of this tutorial is to provide hands on guide to mosaic and subset the satellite images. For mosaicking a multi-spectral satellite image, same procedure needs to be followed and applied on each band individually.

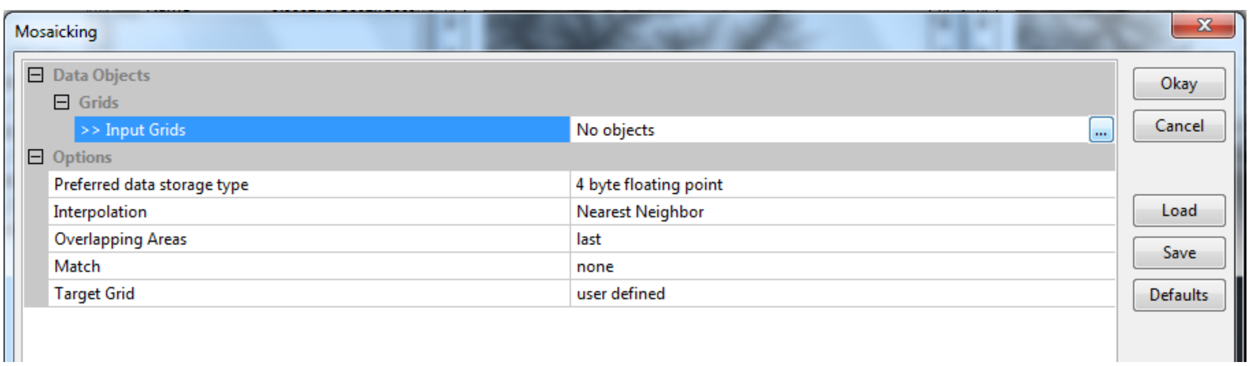
Load the images in SAGA by clicking on the 'Load' button. In the window that pops up, navigate to the tutorial data. The layers may not be immediately visible, so change the dropdown menu selection from 'All Recognized files' to 'All files'. Select all the four files and click 'Open'.

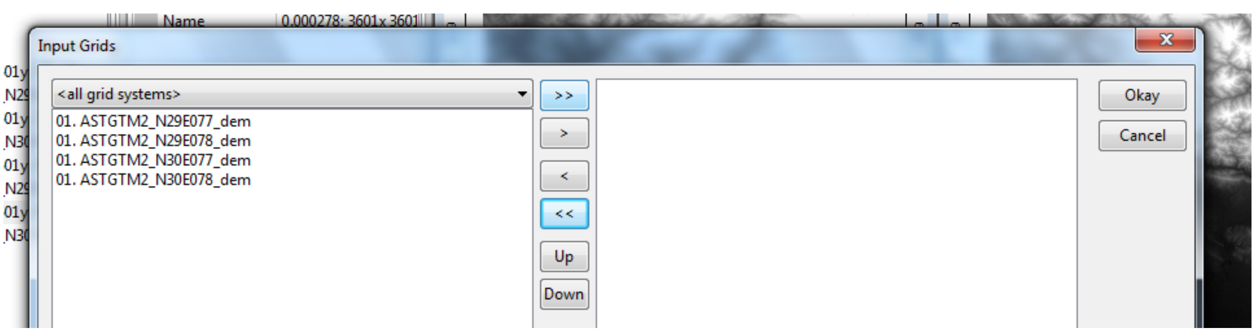
The layers are imported into SAGA now and can be seen in the tab of the Workspace window. They have a slight overlap. We will have to mosaic them.

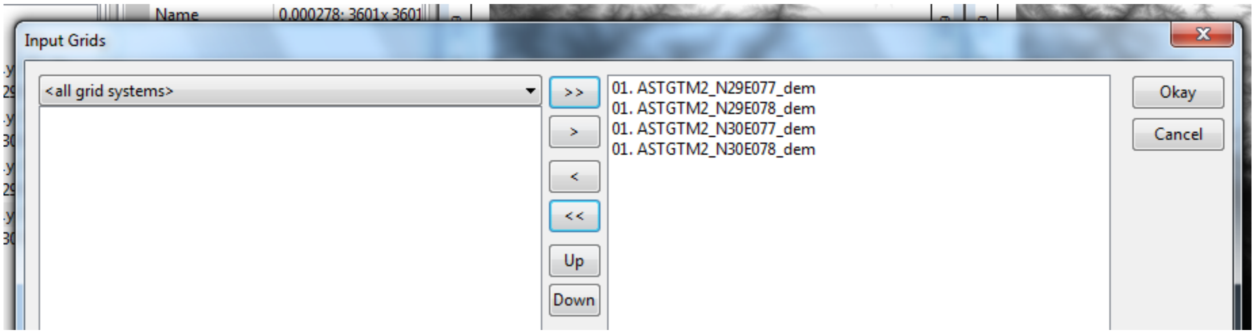


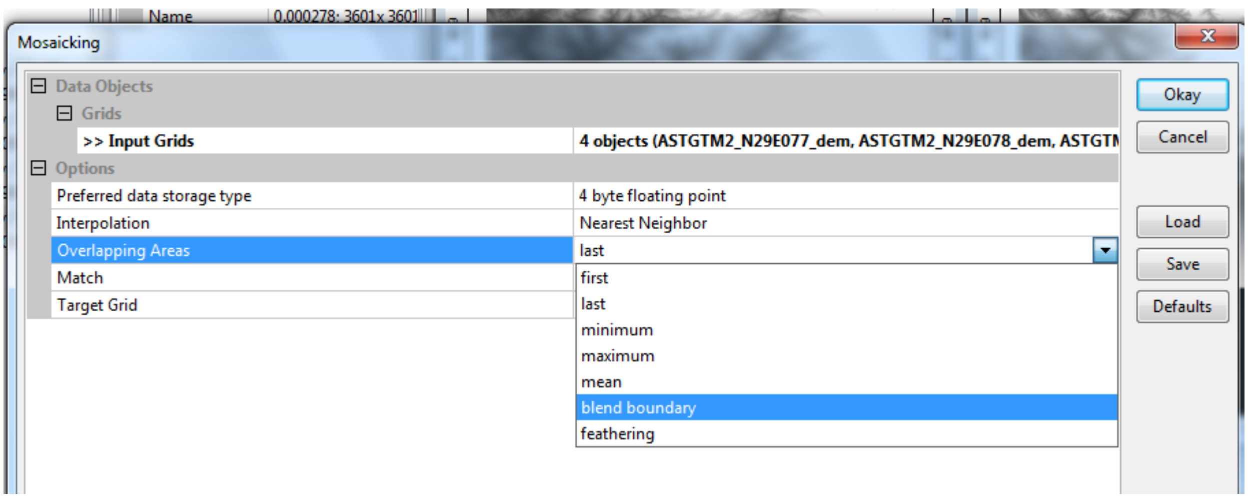
Start mosaicking the image by clicking on Geoprocessing → Grid → Grid System→ Mosaicking. This will open the Mosaicking window. In the field 'Input Grids' click on the button. A window called 'Grids' will open in which we select all the 4 layers and click on the button to send them to the right part of the window. This means that all the images will be mosaicked. Click Okay.


SAGA [E:\Geospatial 2017 SNU\classification_saga\mosaicking.sprj]
File
Geoprocessing
Map
Window
?
Load Tool Library
Find and Run Tool
Climate
Database
File
Garden
Grid
Imagery
Projection
Shapes
Simulation
Spatial and Geostatistics
TIN
Table
Terrain Analysis
Analysis
Calculus
Distances
Filter
Gaps
Grid System
Gridding
Values
Visualisation
Aggregate
Clip Grids
Clip Grids [interactive]
Create Grid System
Crop to Data
Mosaicking
Resampling
Tiling
Transpose Grids
Settings
Description
Options
Name
01. ASTGTM2_N30E078_dem
01. ASTGTM2_N30E077_dem
01. ASTGTM2_N29E078_dem
Data Source
ODBC
PostgreSQL
File System
classification_saga
Cluster Analysis.txt
Clusters.sgrd
Composite.sgrd
Composite_1.sgrd
Mosaic.sgrd
mosaicking.sprj
signature_samples.dbf
Apply
Restore
Load
Save

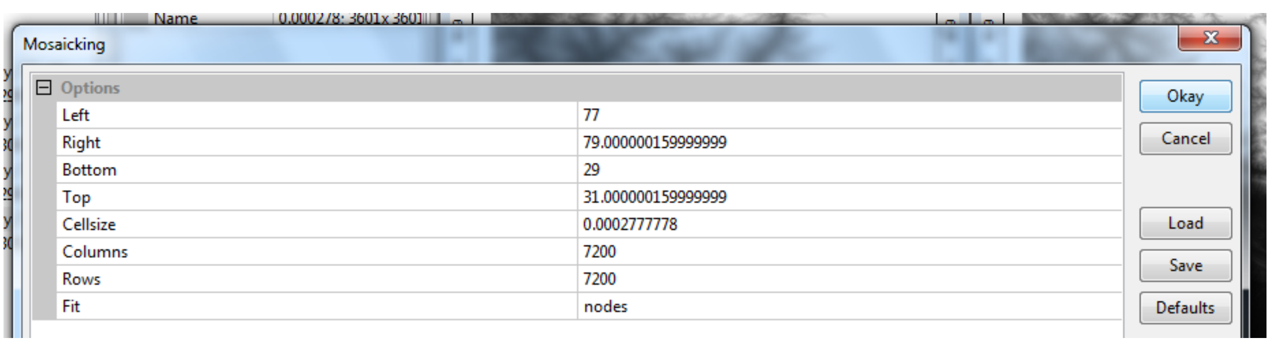

Mosaicking
Data Objects
Grids
>> Input Grids
No objects
Options
Preferred data storage type
4 byte floating point
Interpolation
Nearest Neighbor
Overlapping Areas
last
Match
none
Target Grid
user defined
Okay
Cancel
Load
Save
Defaults


Input Grids
<all grid systems>
01. ASTGTM2_N29E077_dem
01. ASTGTM2_N29E078_dem
01. ASTGTM2_N30E077_dem
01. ASTGTM2_N30E078_dem
>>
>
<
<<
Up
Down
Okay
Cancel



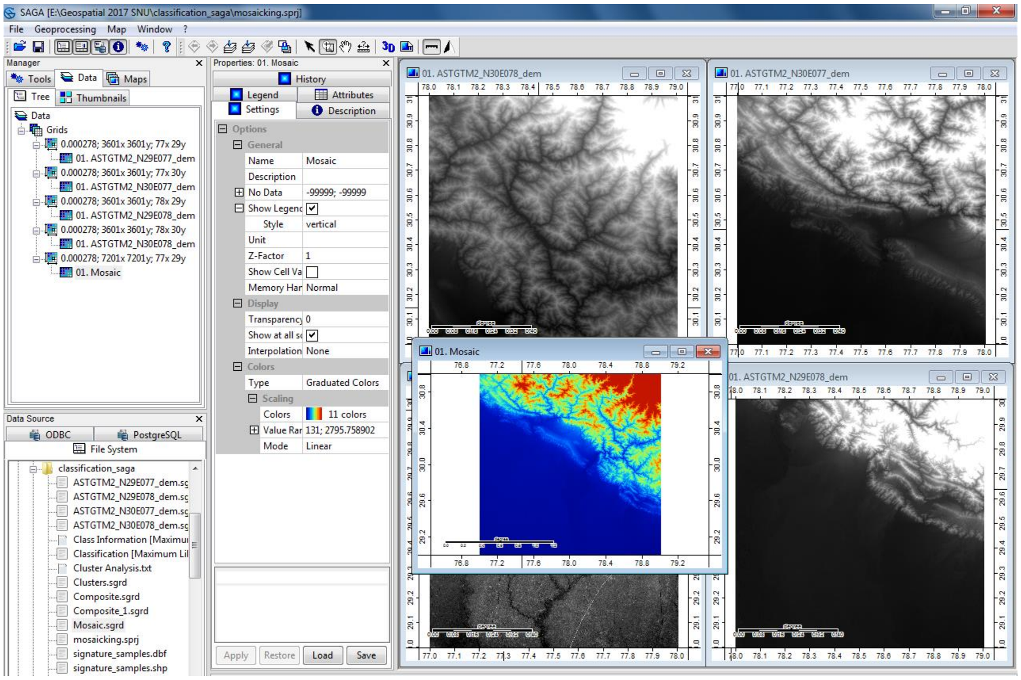


In 'Mosaicking' windows, change the resampling to 'Nearest Neighbor', Overlapping Areas to 'blend boundary' and leave the Target Grid to User Defined and Click 'Okay'. Another window appears showing the Mosaicking options. Click 'Okay'.

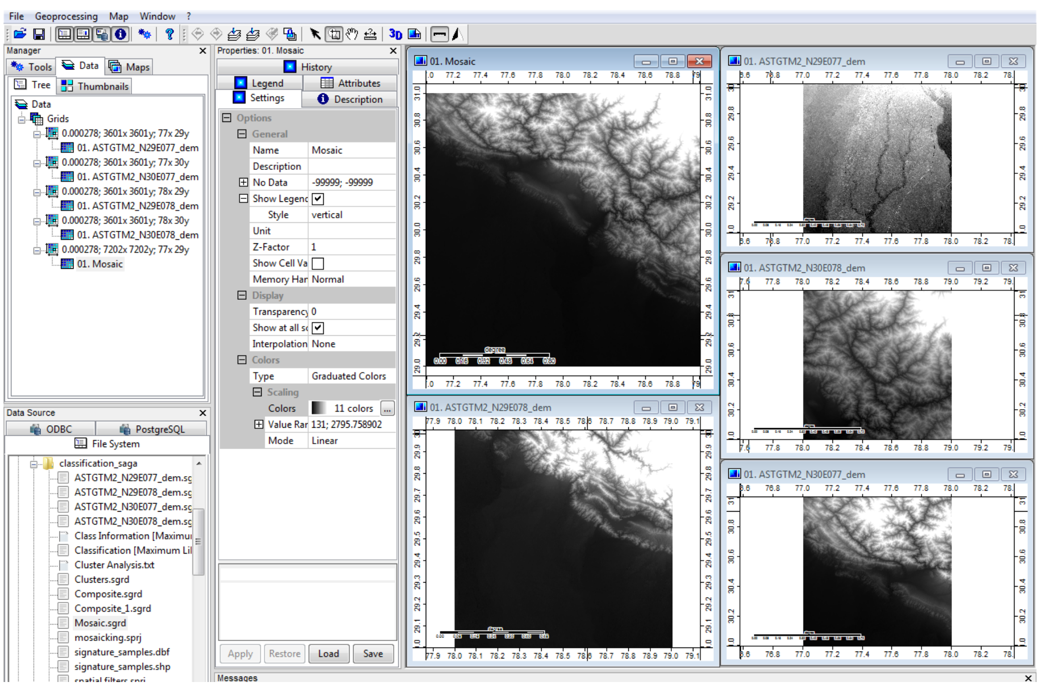


The merged grid will appear in a separate grid as 'Mosaic' under Data tab. We can remove the original images from the data list by right-clicking on their grids and selecting 'Close' (Click on 'Yes' and 'Close' in the successive prompt windows).

Right-click on an image and select 'Add to Map'. The full image will have opened up in the Map Area



Change the color of the mosaicked image to greyscale by referring to earlier tutorials.

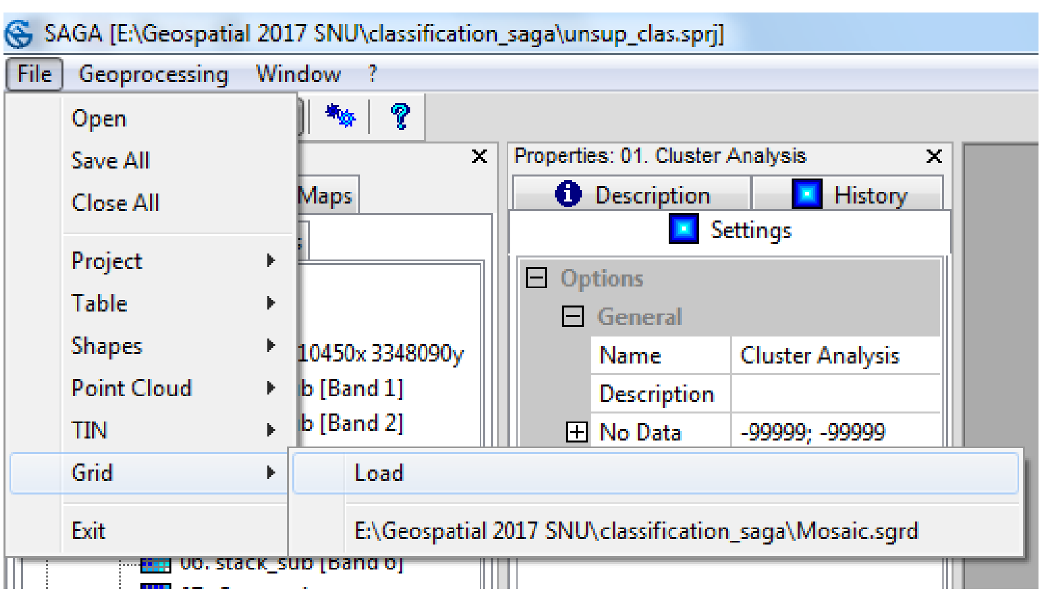


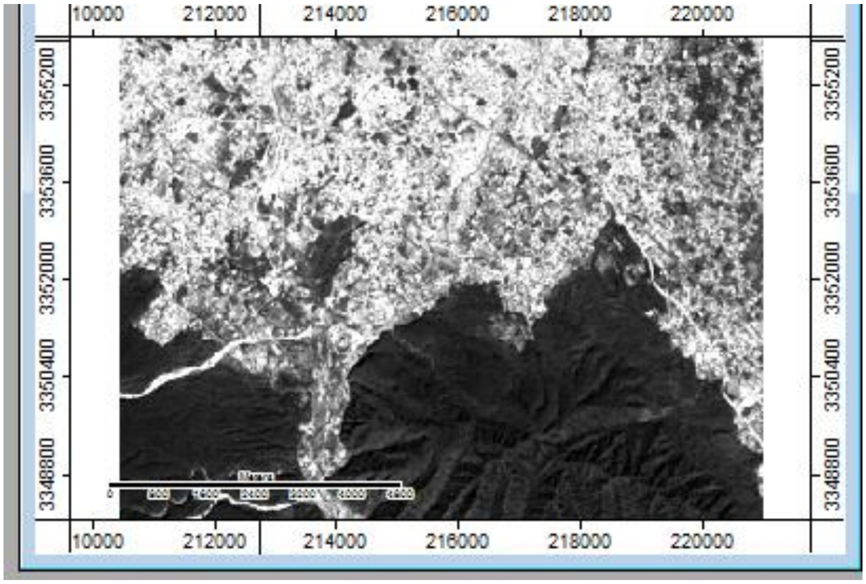
UNSUPERVISED CLASSIFICATION

To create a land use and land cover map of an area, we have to assign corresponding land use and land cover type to every pixel in the satellite imagery that exist at the time of acquisition. This is done based on the Digital Number (DN) values of the pixel which in turn represent the spectral properties of the ground surface. This assigning of classes to pixels in an image is called 'Image classification'. More technically, it is an aspect of image processing in which quantitative decisions are made on the basis of the data present in the image, grouping pixels or regions of the image into classes representing different ground-cover types. The output of the classification stage may be regarded as a thematic map rather than an image (Rees, 1999). Two broad types of image classification exist – 'Supervised classification' and 'Unsupervised classification'. In this tutorial we will learn how to classify an image using the unsupervised method.

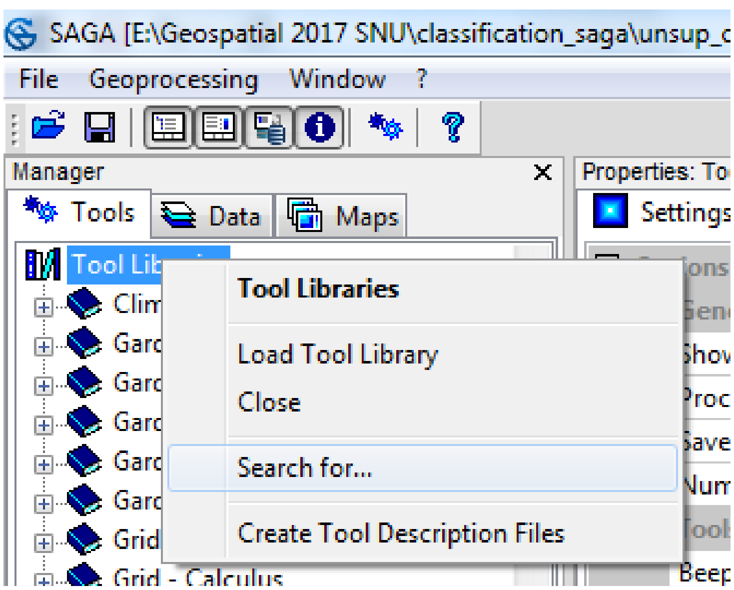
In unsupervised classification, the algorithm analyzes all the bands of the image and pick out the clusters of pixels having similar values without the user intervention. The clusters are then assigned to their classes at the user's discretion. Therefore, this method generally applied to the regions, where we don't have any knowledge and information about land cover type. In this tutorial, we will use a stacked image with bands 2 to 7 (labelled as 1 to 6) of Landsat 8 to create a land cover map of Dehradun and its surrounding region.

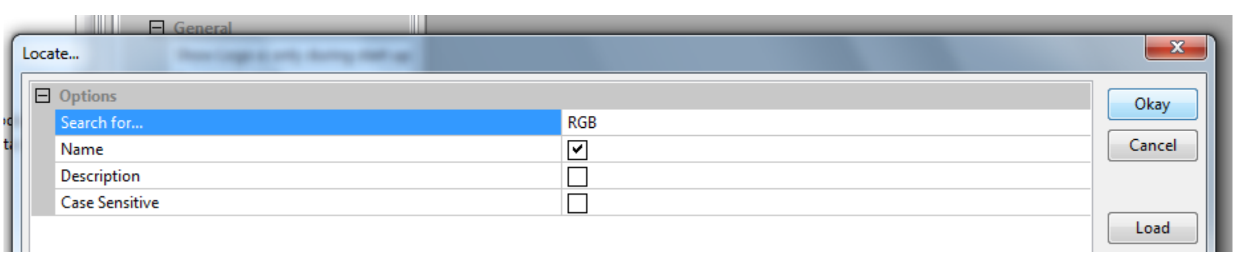
Load the Landsat image into SAGA by clicking on the 'Load File' button or via File → Grid → Load. Select the 'stack_sub' image. This will import the image into SAGA.

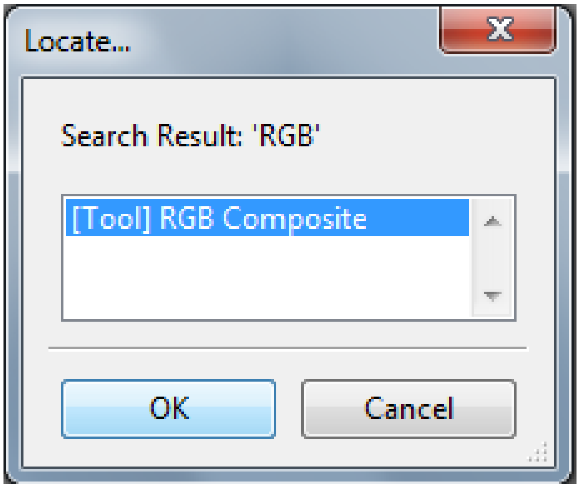


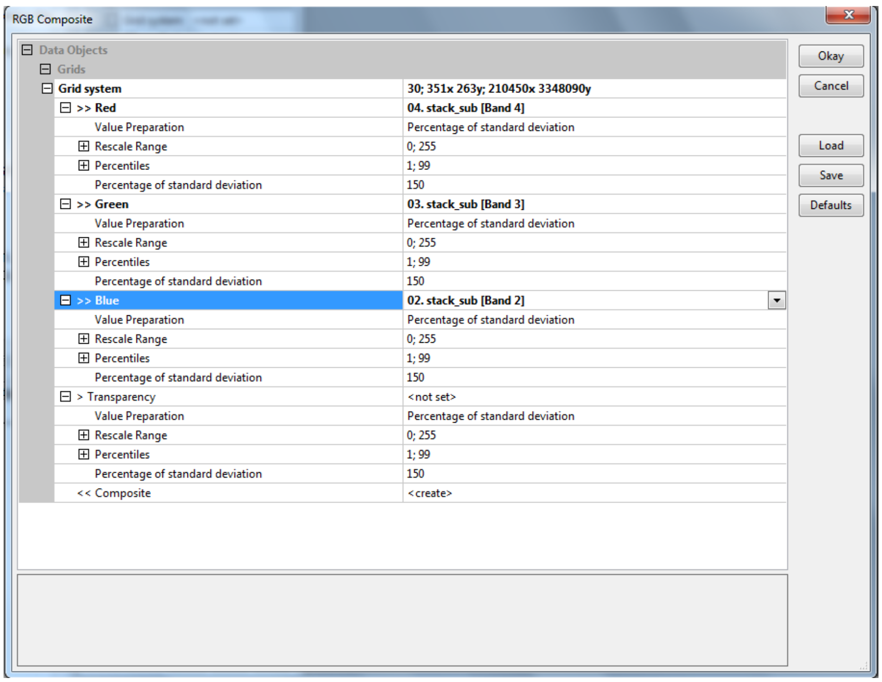


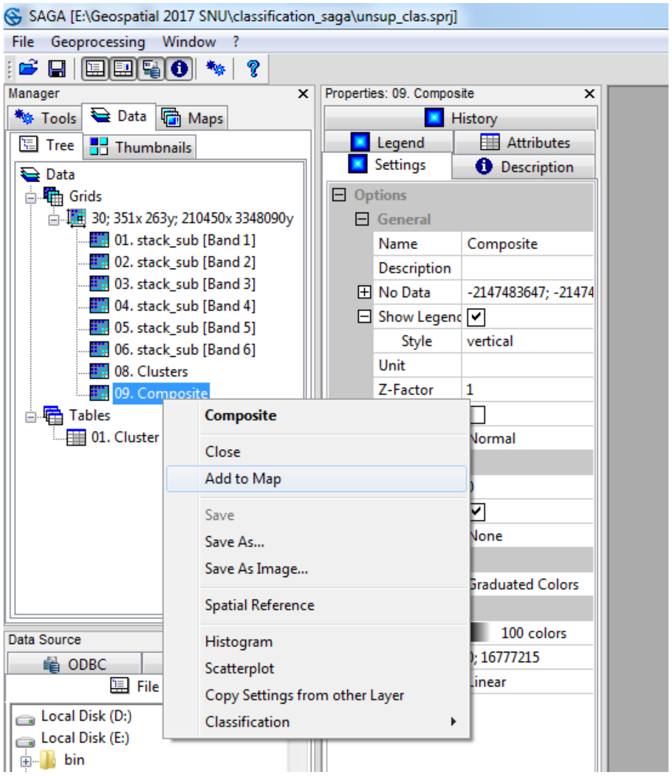
Since different features are not easily identifiable in single band image, we will prepare a FCC composite for the same. The steps are given below.

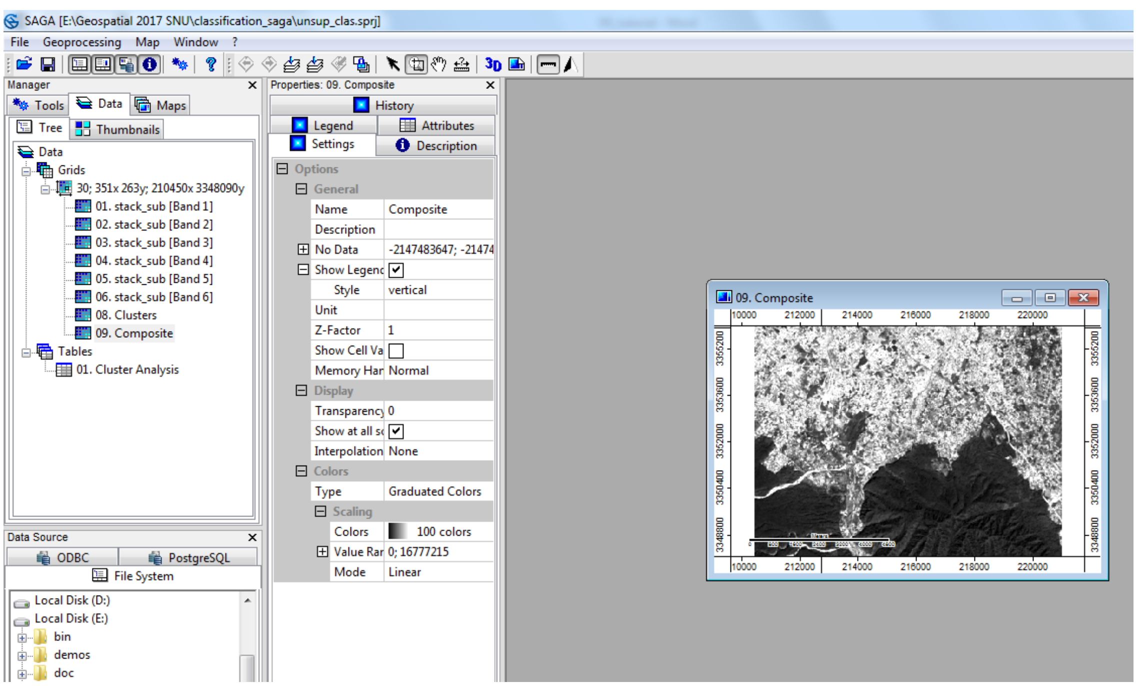




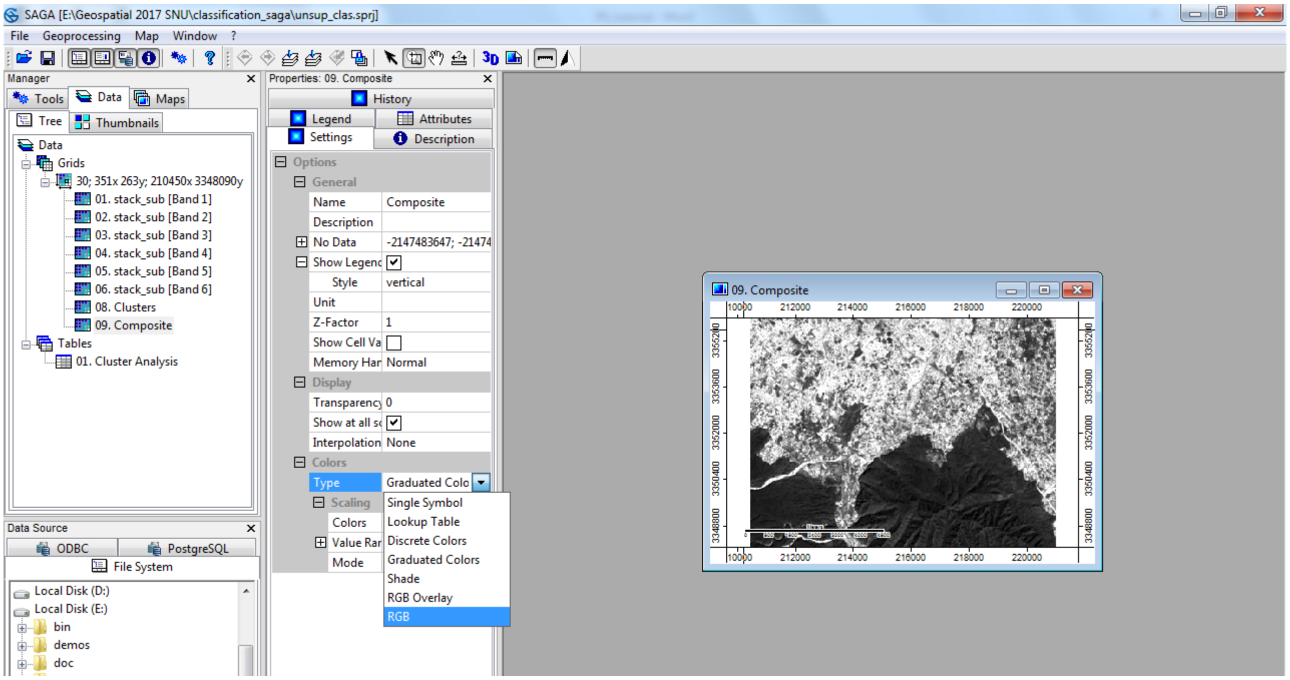

Locate...
Search Result: 'RGB'
[Tool] RGB Composite
OK
Cancel

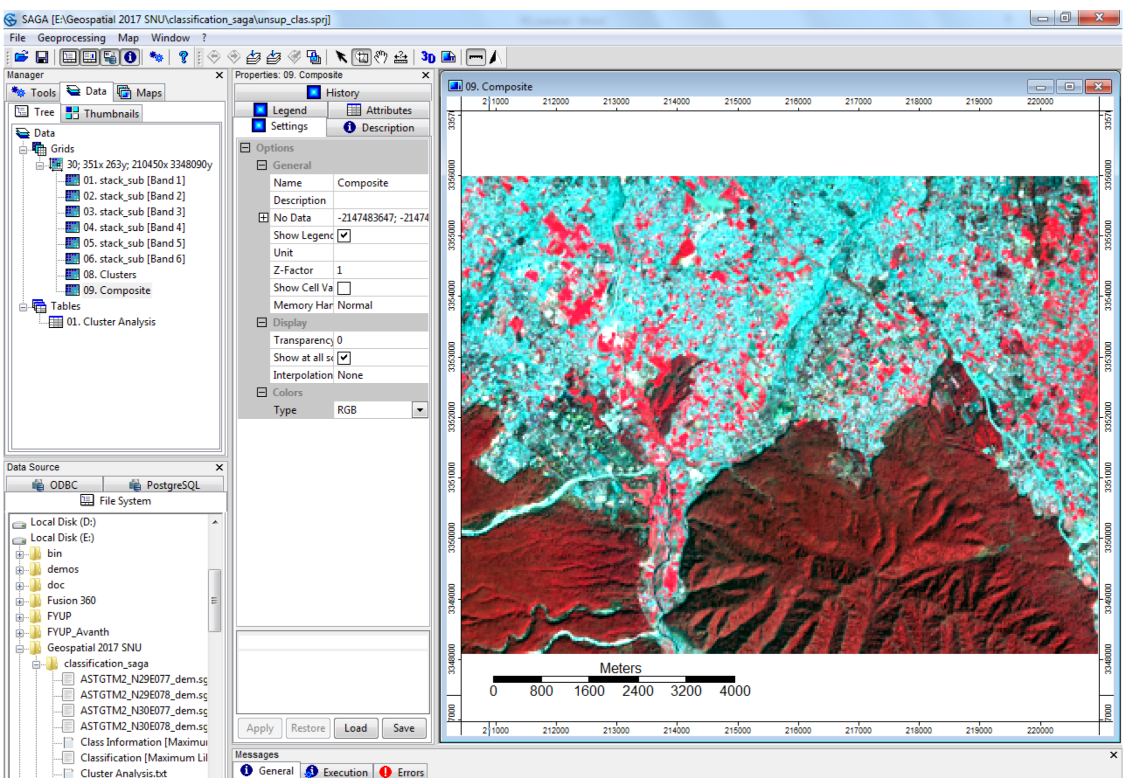

RGB Composite
Data Objects
Grids
Grid system
30; 351x 263y; 210450x 3348090y
>> Red
04. stack_sub [Band 4]
Value Preparation
Percentage of standard deviation
Rescale Range
0; 255
Percentiles
1; 99
Percentage of standard deviation
150
>> Green
03. stack_sub [Band 3]
Value Preparation
Percentage of standard deviation
Rescale Range
0; 255
Percentiles
1; 99
Percentage of standard deviation
150
>> Blue
02. stack_sub [Band 2]
Value Preparation
Percentage of standard deviation
Rescale Range
0; 255
Percentiles
1; 99
Percentage of standard deviation
150
> Transparency
<not set>
Value Preparation
Percentage of standard deviation
Rescale Range
0; 255
Percentiles
1; 99
Percentage of standard deviation
150
<< Composite
<create>
Okay
Cancel
Load
Save
Defaults



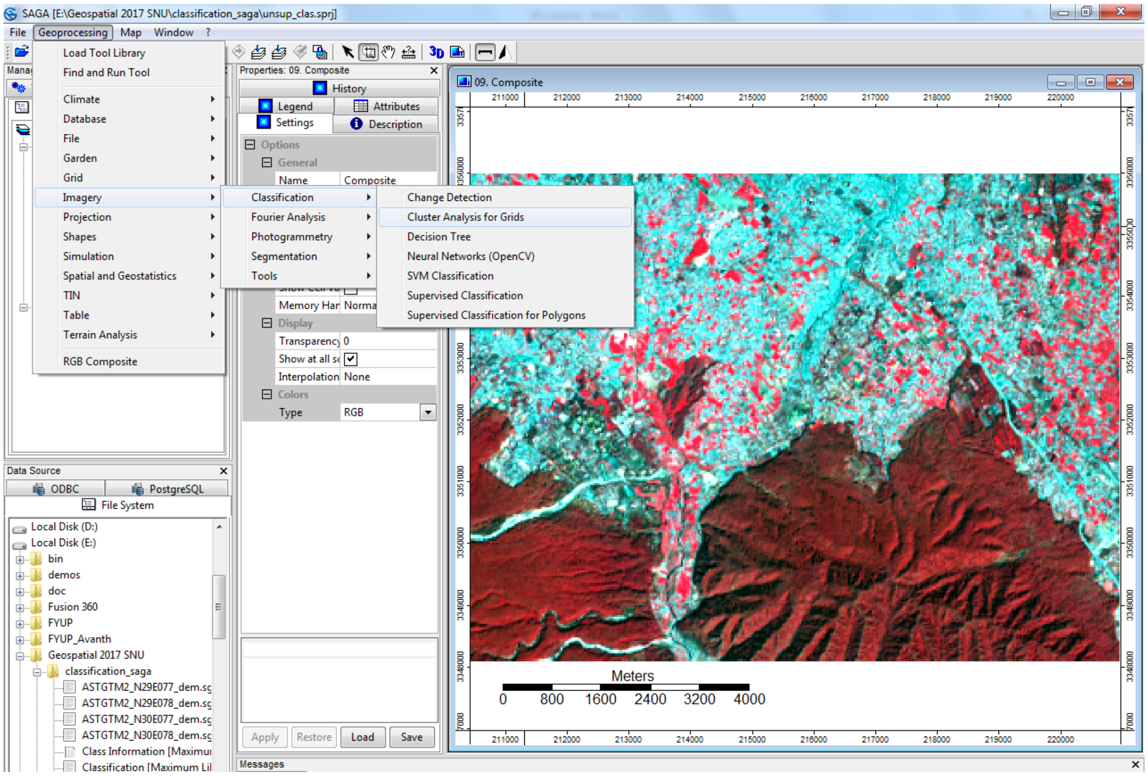


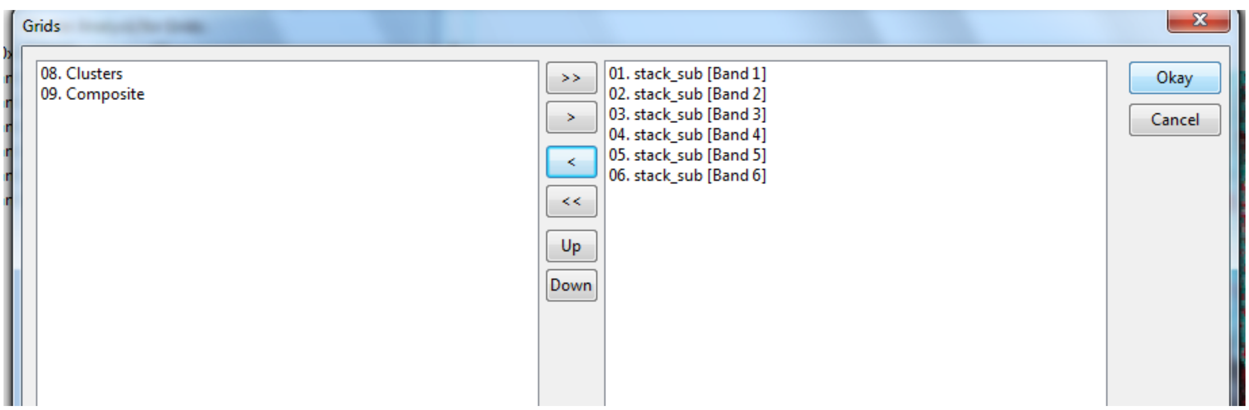
Change color type from graduate colors to RGB to visualize the composite in FCC. Go to windows and tile horizontally.





Now we will classify the image using Geoprocessing → Imagery → Classification → Unsupervised → Cluster analysis for Grids (ISODATA). Select all bands and move to the right and click okay.





The module window options are explained below.

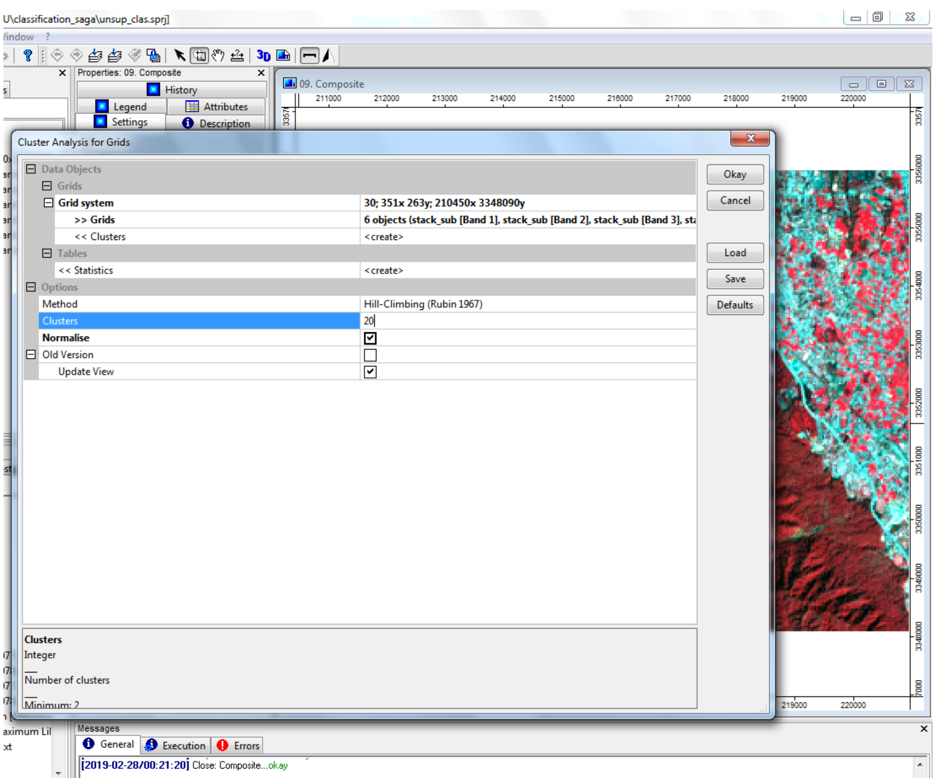
Grid System: This is grid system of the image to be classified. Select it from the drop-down menu.

>>Features: These are the input grid layers that will be used in the classification. Click on the button and select the Landsat layer/s and click on the button and click on 'Okay'.

<<Clusters: This is the output option for the clustered image. To create a new image, we keep it as '[create]'. If we are running the cluster analysis for the second time and want to overwrite an image then select the image to be overwritten from the dropdown menu.

<<Statistics: This creates a table with the statistics of the band layers and the clusters. By default, it is set as '[create]' but we can overwrite an existing table by selecting it from the dropdown menu.

Options: Specify the options as shown below



On clicking 'Okay', the cluster analysis will start and will keep reiterating the search. You can see the progress on the left side of the status bar located at the bottom of SAGA GUI.

The classified image titled 'Clusters' is placed in the Landsat image grid system. Double click on it to open in the 'True Colour Composite' map list.

This newly created cluster map splits the image area into homogenous land cover segments. We now have to assign each cluster to its land cover class.

Before doing that we have to assign a unique number to each land cover class. We will use a simple 5 class classification. You may use the ones below or select your own.

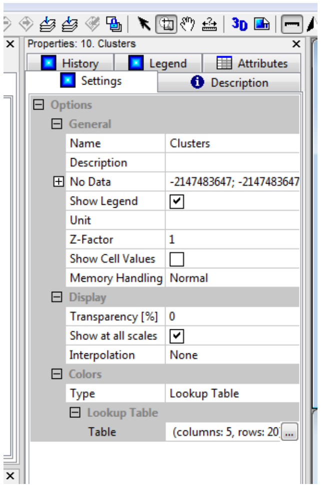
Insert table

Class number	Class Name
1	Dense Forest
2	Open Forest
3	Agriculture
4	Non-Forest
5	River Bed

Now turn on and off the cluster layer in the Map window. You will see that the clusters take the shape of some land features. This way we can identify the clusters based on their shape, location and image pixel values.

Select the 'Clusters' layer from the data list and click on the tab. This will display the different class numbers and their associated colour. To check which cluster a pixel belongs to, just mouse over the pixel and look at the Status Bar at the bottom of the SAGA window. This displays the 'Z value' of the pixel. In this case the Z value is the class number.

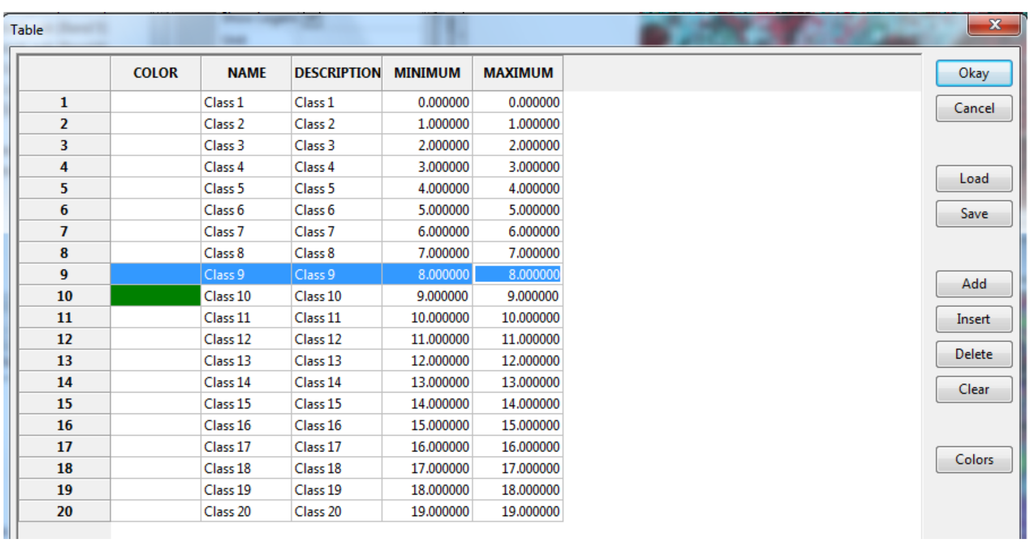
We will start assigning class numbers to the clusters by selecting the layer and then accessing the tab. Click the button under 'Table' to open the lookup table. This will give the clusters information with five fields: COLOUR, NAME, DESCRIPTION, MINIMUM and MAXIMUM.



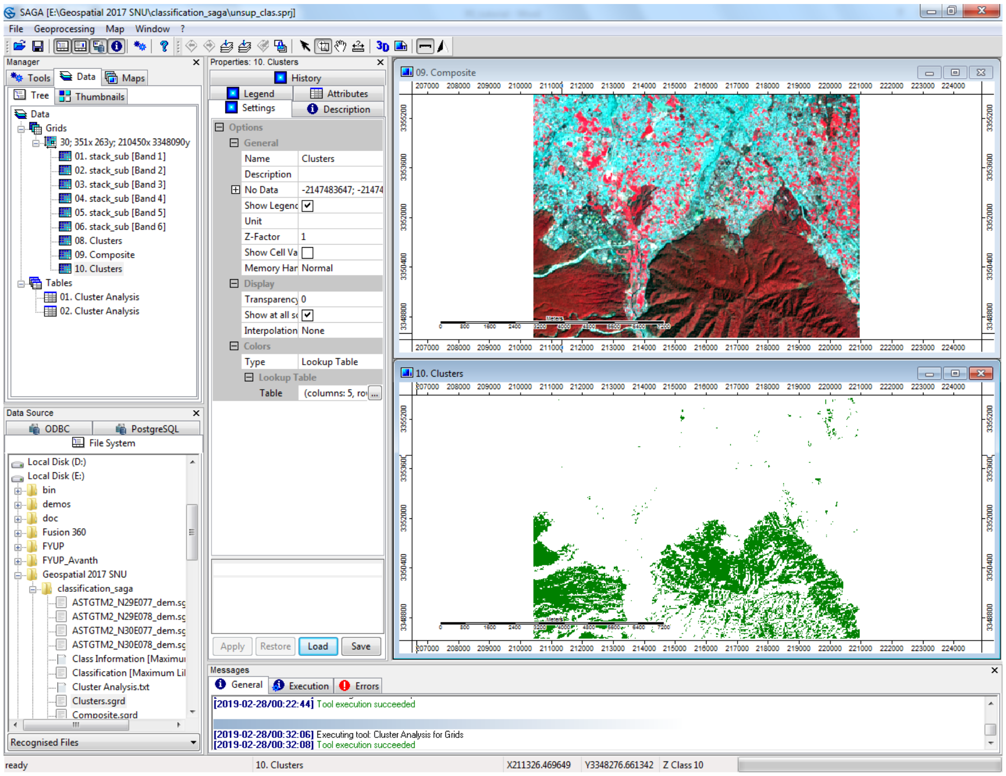
The color of a cluster can be changed by clicking on it and choosing a color from the palette. The MINIMUM and MAXIMUM fields indicate the cluster number and will have the same value in this table. The numbering of the clusters starts from 0. Therefore, Class 1 would be numbered 0, Class 2 would be numbered 2, and so on.

Identifying classes and the land cover they represent can become difficult when looking at the cluster map with all its classes. To make it easier, we will handle them one at a time.

Tile both the RGB and the unsupervised classification output. In the attribute table turn all the layers as white and give color to a class one by one and identify the type of land covered by this cluster using the false color or true color composites. For example, let's look at the first cluster.



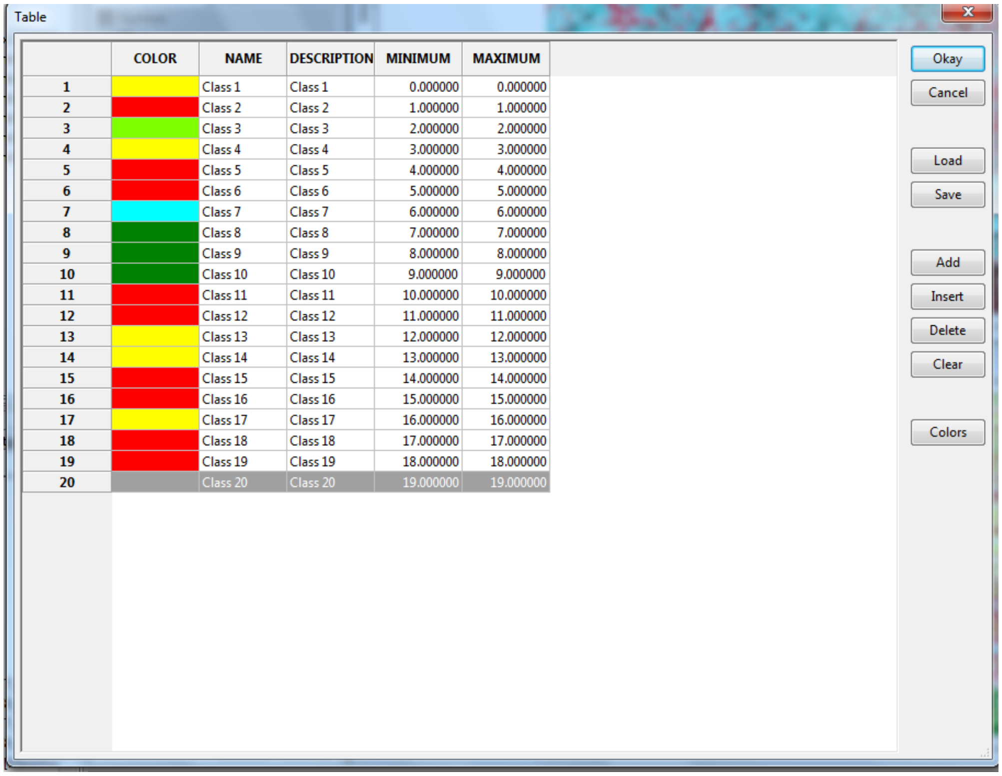
	COLOR	NAME	DESCRIPTION	MINIMUM	MAXIMUM
1		Class 1	Class 1	0.000000	0.000000
2		Class 2	Class 2	1.000000	1.000000
3		Class 3	Class 3	2.000000	2.000000
4		Class 4	Class 4	3.000000	3.000000
5		Class 5	Class 5	4.000000	4.000000
6		Class 6	Class 6	5.000000	5.000000
7		Class 7	Class 7	6.000000	6.000000
8		Class 8	Class 8	7.000000	7.000000
9		Class 9	Class 9	8.000000	8.000000
10		Class 10	Class 10	9.000000	9.000000
11		Class 11	Class 11	10.000000	10.000000
12		Class 12	Class 12	11.000000	11.000000
13		Class 13	Class 13	12.000000	12.000000
14		Class 14	Class 14	13.000000	13.000000
15		Class 15	Class 15	14.000000	14.000000
16		Class 16	Class 16	15.000000	15.000000
17		Class 17	Class 17	16.000000	16.000000
18		Class 18	Class 18	17.000000	17.000000
19		Class 19	Class 19	18.000000	18.000000
20		Class 20	Class 20	19.000000	19.000000



We see that the cluster covers 'Dense forest' land cover. So, we mark in the NAME column as 'Dense Forest' and color to 'dark green'.

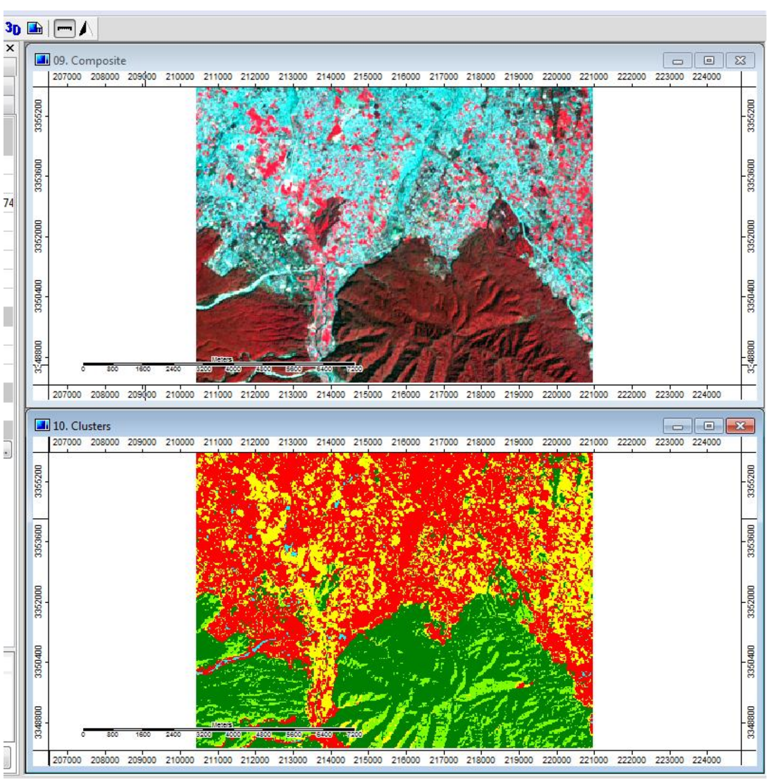
Go to the next cluster below and Change its colour to 'Yellow or some other bright color'. Click 'Okay' and then 'Apply'. The next cluster will now be visible. Repeat the same procedure.

Repeat the last two steps till all the clusters have been assigned a class number.



	COLOR	NAME	DESCRIPTION	MINIMUM	MAXIMUM
1		Class 1	Class 1	0.000000	0.000000
2		Class 2	Class 2	1.000000	1.000000
3		Class 3	Class 3	2.000000	2.000000
4		Class 4	Class 4	3.000000	3.000000
5		Class 5	Class 5	4.000000	4.000000
6		Class 6	Class 6	5.000000	5.000000
7		Class 7	Class 7	6.000000	6.000000
8		Class 8	Class 8	7.000000	7.000000
9		Class 9	Class 9	8.000000	8.000000
10		Class 10	Class 10	9.000000	9.000000
11		Class 11	Class 11	10.000000	10.000000
12		Class 12	Class 12	11.000000	11.000000
13		Class 13	Class 13	12.000000	12.000000
14		Class 14	Class 14	13.000000	13.000000
15		Class 15	Class 15	14.000000	14.000000
16		Class 16	Class 16	15.000000	15.000000
17		Class 17	Class 17	16.000000	16.000000
18		Class 18	Class 18	17.000000	17.000000
19		Class 19	Class 19	18.000000	18.000000
20		Class 20	Class 20	19.000000	19.000000

The final classified image looks like this.



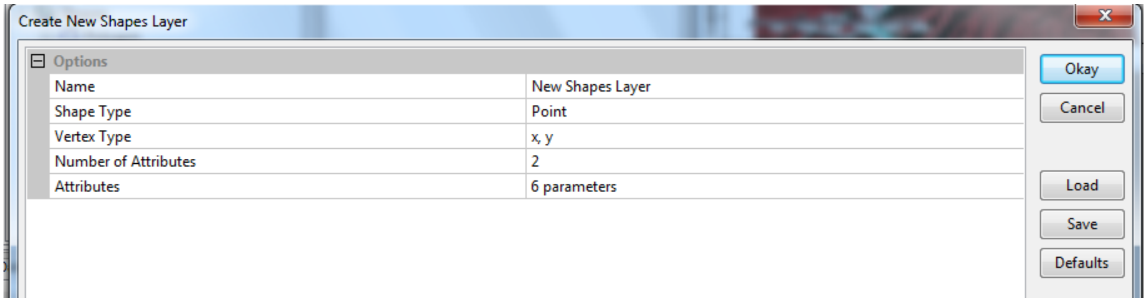
SUPERVISED CLASSIFICATION

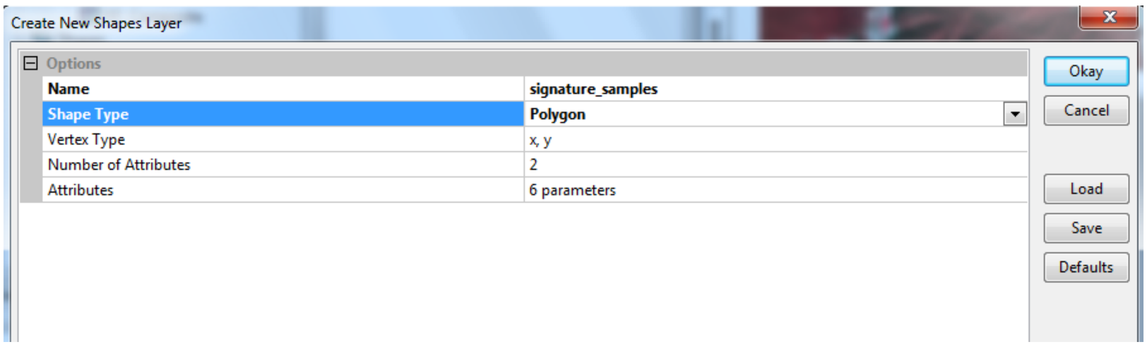
In the previous tutorial, i.e.: 'Unsupervised Classification', we classified the images using the unsupervised method. There are limitations in using this method since we don't have full control over the computer's selection of pixel into clusters. In supervised classification, the user will select a group of pixels belongs to a particular land use / land cover known as training areas or training sites. Based on the pixel values in the training areas the software will create spectral signatures and the statistical information like range, mean, variance etc., of all classes in relation to all input bands. This information has been used to categorize each and every pixel in the image into corresponding land use and land cover class based on the classification algorithm used. Maximum Likelihood (ML), Minimum Distance to Mean (MDM) and Parallelepiped classification algorithms are most commonly used for supervised classification. For brief introduction about the algorithms please read section 8.3.4 'Classification algorithms' in Principles of remote sensing: an introductory textbook of ITC, 2009.

Since, the supervised classification method involves selection of training areas, the user should have a good idea about different land cover classes existing in the study area. This knowledge can be acquired through field verification and other ancillary data. In this tutorial we will use the same Landsat 8 image supplied to you for unsupervised classification. This image was downloaded from the USGS earth explorer website: http://earthexplorer.usgs.gov/

1. Open SAGA Interface → Load the Landsat images into SAGA by clicking on the 'Load File' button or via 'File → Grid → Load'. Select the 'stack_sub' images and click 'Open'. This will import the image into SAGA.

In SAGA, the sample collection is done by using shapefile polygons. Create a shapefile layer via the 'Geoprocessing → Shapes → Construction → Create New Shapes Layer'. Enter 'signature_samples' in the 'Name' field and change the Shape Type to 'Polygon'. Leave the default values in the other three fields. Click 'Okay'.

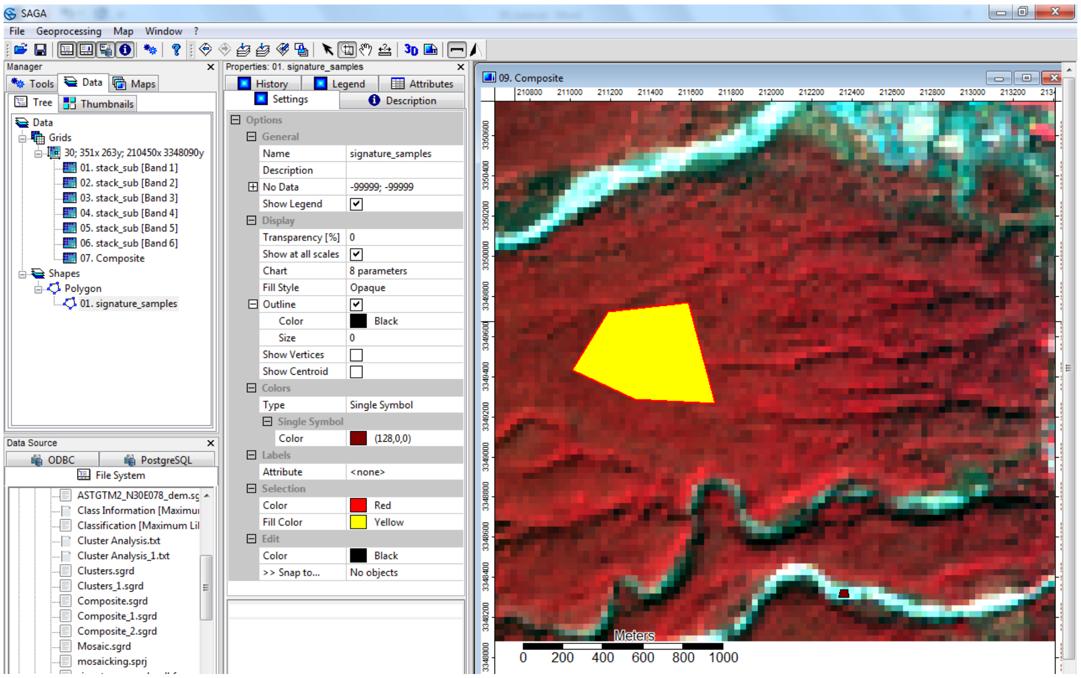




A polygon named 'signature_samples' will be created and placed in the 'Data' list under the Shapes. Add this polygon layer to the map (False color composite) on which you would like to create the sample polygons by double clicking on the 'signature_samples' shape file → Now select 'stack_sub' from the popup window i.e., 'Add layer to selected Map' → 'OK'.

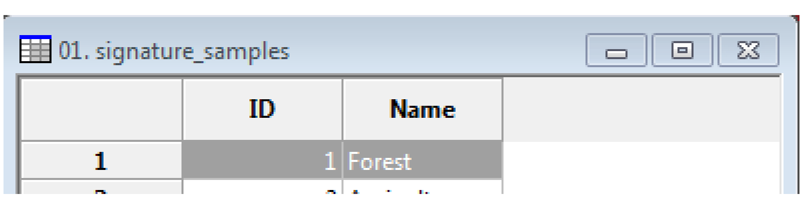
In order to pick up training areas, we have to enable the editing mode of shape file. To start editing, Right-click on 'signature_samples' shapefile → Edit → Edit selection or Select the Action button from 'Tool Bar' or from 'Main menu bar → Map → Action' and then Right click on the map → Add Shape. This will change the cursor to a '+' sign.

Zoom in to the forests in the left of the image. Create the sample shape by clicking around a bright red forest patch. When you are outlining be precise to select as many similar looking pixels as possible within a single polygon.



The signature sample is listed in the polygon attribute table. To open the attribute table: 'Right-click on polygon layer → Attributes → Show'. The attribute table will open with two fields – ID and Name. By single / double click on the corresponding cell you can able to change vales in table. Type the name as 'Forest'. The ID field is filled in as 0, change this to the corresponding class number as per the following table below. For 'Forest' the corresponding ID is '1'.

Class Number	Class Name
1	Forest
2	Agriculture
3	Built-up
4	River bed

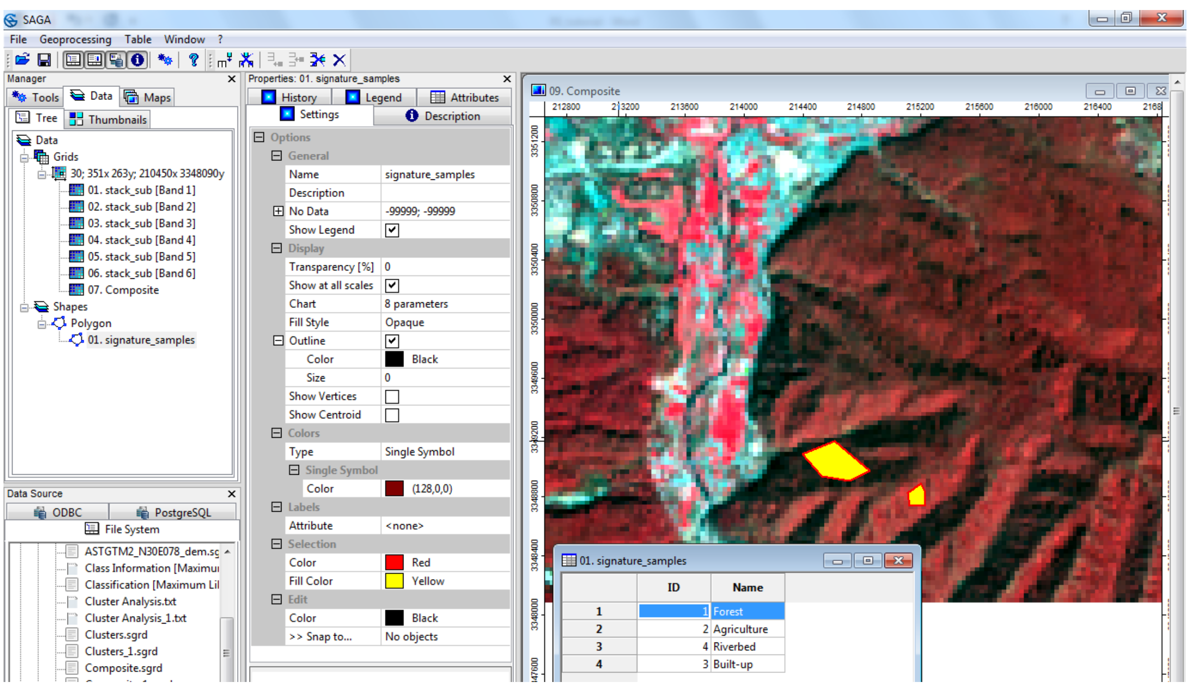


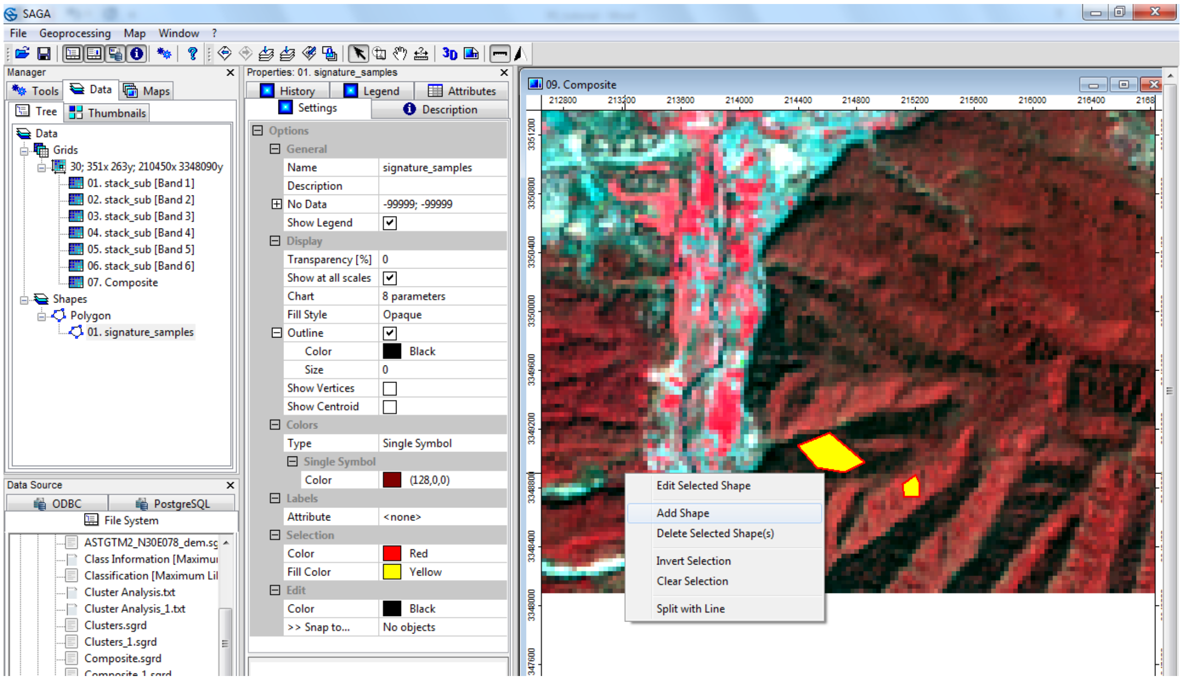
Note: While creating sample shapes, draw the boundary on the inside edge of a feature. This will ensure that a purer signature is picked up from this sample. Make sure that a signature contains only pixels of the interested land cover/use class. If other class pixels are present it will dilute the quality of the signature.

A few things to keep in mind while digitizing the signatures in SAGA:

a. The Right-click → Edit operations may not always work via the Maps tab and the Map Window. At this time you have to select Action tool before doing it again.
b. If you notice no tool bar on the under main menu, which contains Action, Zoom, Pan and other tools, click on Map window to access them.

We must therefore pickup signature for every variation of forest for accurate classification. Zoom in to the shaded forest, then select 'Forest' row from the attribute table. Be sure that the row is highlighted in blue color and as well as the first Forest polygon in yellow. Now navigate to the forest area in shadow, looks Dark red in false color composite formed in previous step in the map window.

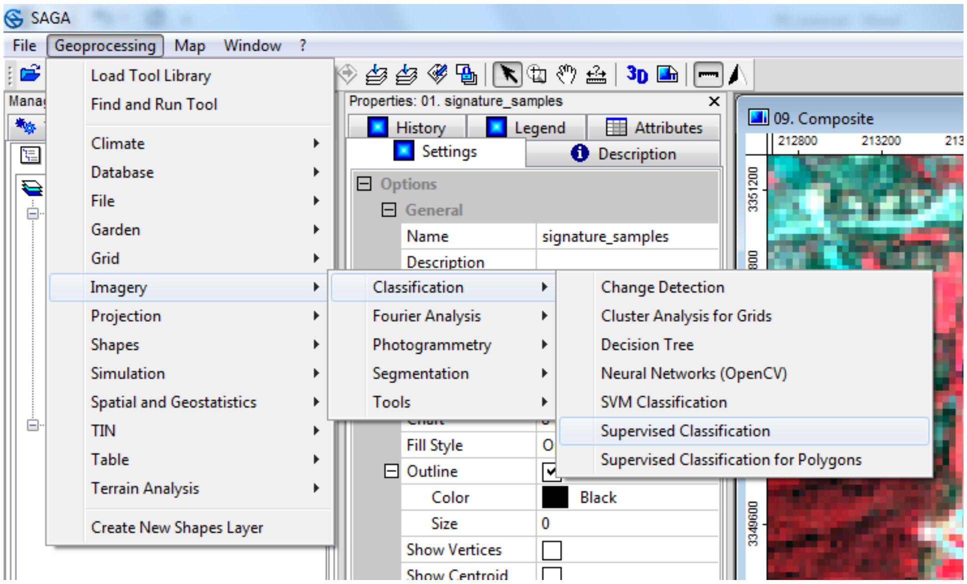


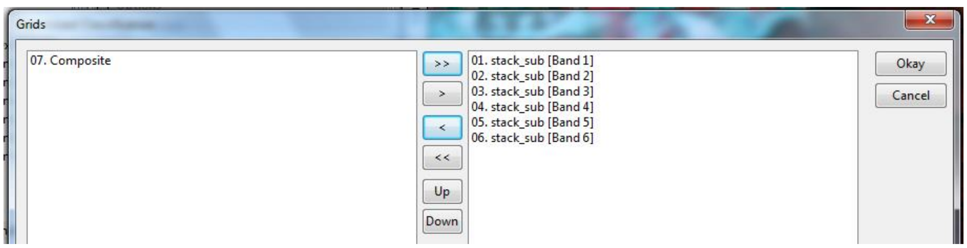


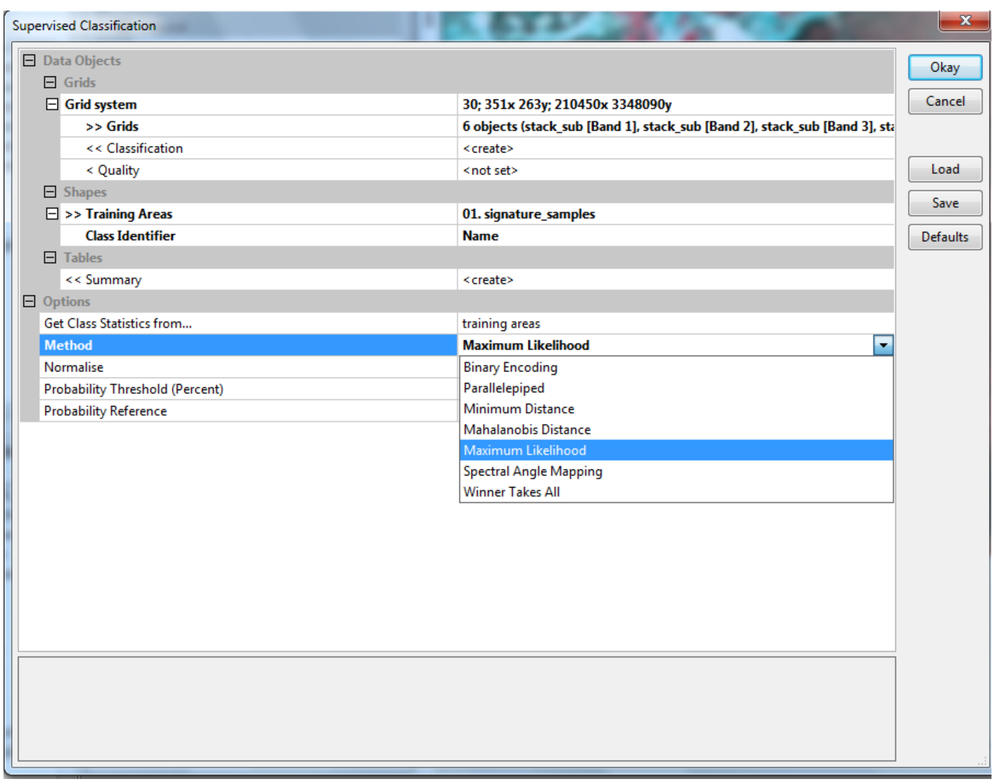
Now, click on Action and then right-click on the Map → select 'Edit Selected Shape'→ You can notice the first forest shape changed in to editing mode →Once again right-click on the Map → Select 'Add Part' → create a signature for forest area in shadow as well → 'Right click' to finish the polygon. Repeat this process to cover all variations of forest. Save the shape by Right-click (once/twice) → Uncheck 'Edit Selected Shape'. Now you can see that all forest variations are add to the same signature 'Forest'.

Similarly use Add Shape option to create a new land cover / land use class and 'Add part' option to pickup variation of it. Now collect signatures for the rest of the classes presented in the table under previous steps.

Once you are done with the signature collection, now you are ready to run Supervised classification module. Open it via 'Geoprocessing → Imagery → Classification → Supervised Classification' module. Set the values for Grid system, Grids, Training Areas and Class Identifiers as shown below.


SAGA
File
Geoprocessing
Map
Window
?
Load Tool Library
Find and Run Tool
Climate
Database
File
Garden
Grid
Imagery
Projection
Shapes
Simulation
Spatial and Geostatistics
TIN
Table
Terrain Analysis
Create New Shapes Layer
Properties: 01. signature_samples
History
Legend
Attributes
Settings
Description
Options
General
Name
signature_samples
Description
Classification
Fourier Analysis
Photogrammetry
Segmentation
Tools
Change Detection
Cluster Analysis for Grids
Decision Tree
Neural Networks (OpenCV)
SVM Classification
Supervised Classification
Supervised Classification for Polygons
Fill Style
Outline
Color
Black
Size
0
Show Vertices
Show Centroid
09. Composite
212800
213200
3351200
3349600


Grids
07. Composite
>>
>
<
<<
Up
Down
01. stack_sub [Band 1]
02. stack_sub [Band 2]
03. stack_sub [Band 3]
04. stack_sub [Band 4]
05. stack_sub [Band 5]
06. stack_sub [Band 6]
Okay
Cancel


Supervised Classification
Data Objects
Grids
Grid system
30; 351x 263y; 210450x 3348090y
>> Grids
6 objects (stack_sub [Band 1], stack_sub [Band 2], stack_sub [Band 3], sta
<< Classification
<create>
< Quality
<not set>
Shapes
>> Training Areas
01. signature_samples
Class Identifier
Name
Tables
<< Summary
<create>
Options
Get Class Statistics from...
training areas
Method
Maximum Likelihood
Normalise
Probability Threshold (Percent)
Probability Reference
Binary Encoding
Parallelepiped
Minimum Distance
Mahalanobis Distance
Maximum Likelihood
Spectral Angle Mapping
Winner Takes All
Okay
Cancel
Load
Save
Defaults

The 'Grid system' entry will be the grid system of our input data set. For the

a) >>'Feature', click on the button to the right of the field. In the dialogue popup window, we select the Landsat Image and click on the button. This will transfer the layers to the right which indicates that they will be used by the module. Click 'Okay'.

b) '>>Classification' as '[Create]'. The Quality option allows us to create an image which describes the quality of the classification for every pixel. The image values vary with the type of classification, here will select '[not set]'.

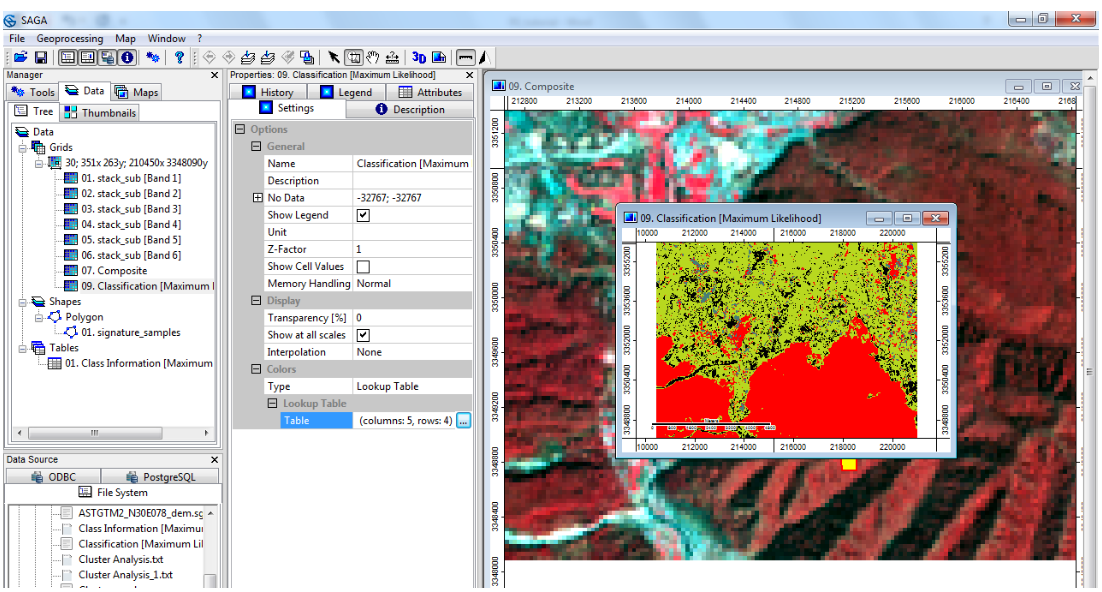
c) '>>Training Areas' input is the shapefile containing all the signature shapes. Set it as 'signature_samples'.

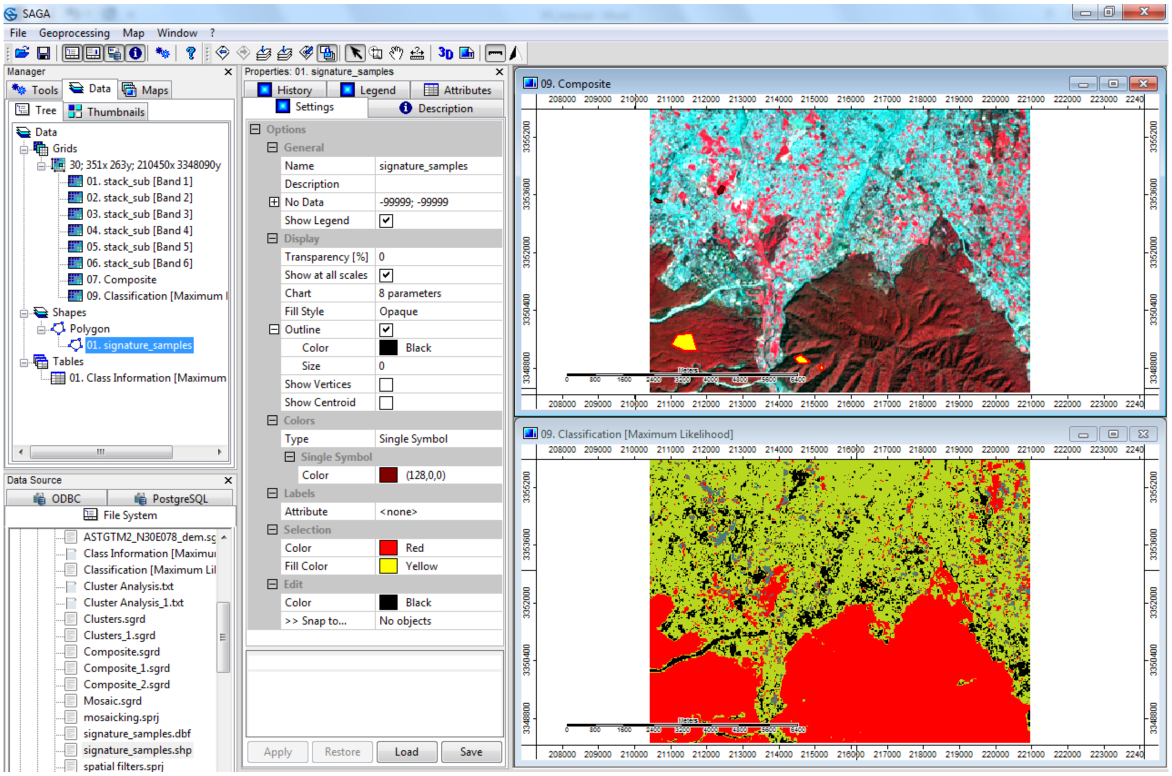
d) The 'Class Identifier' is the field with which we differentiate the classes. The classes will be named according to this field. Set it as 'ID' or 'Name'. By using this text field, we can easily identify and relate the sample area description with the class.

e) Set the Method option as 'maximum likelihood' and leave others as default.

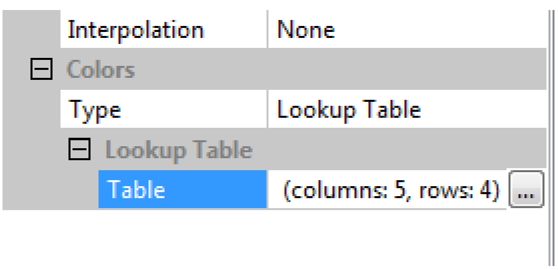
f) Click on 'Okay' to proceed for maximum likelihood supervised classification.

The classified image will look something like the image below. The image has been split into 4 classes, with each class coming from one set of signature polygons.

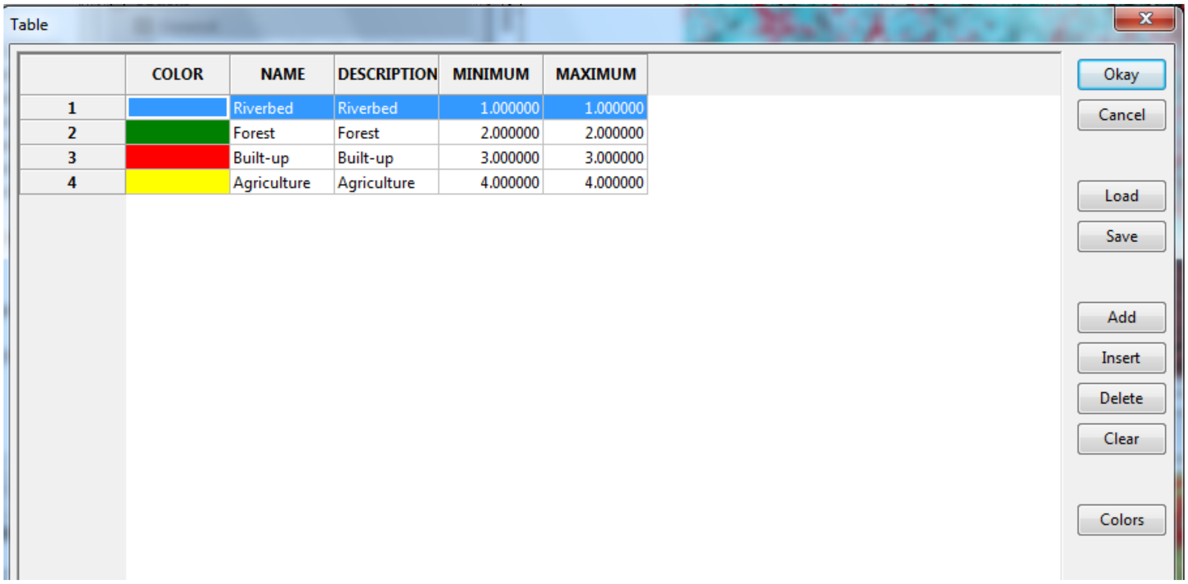


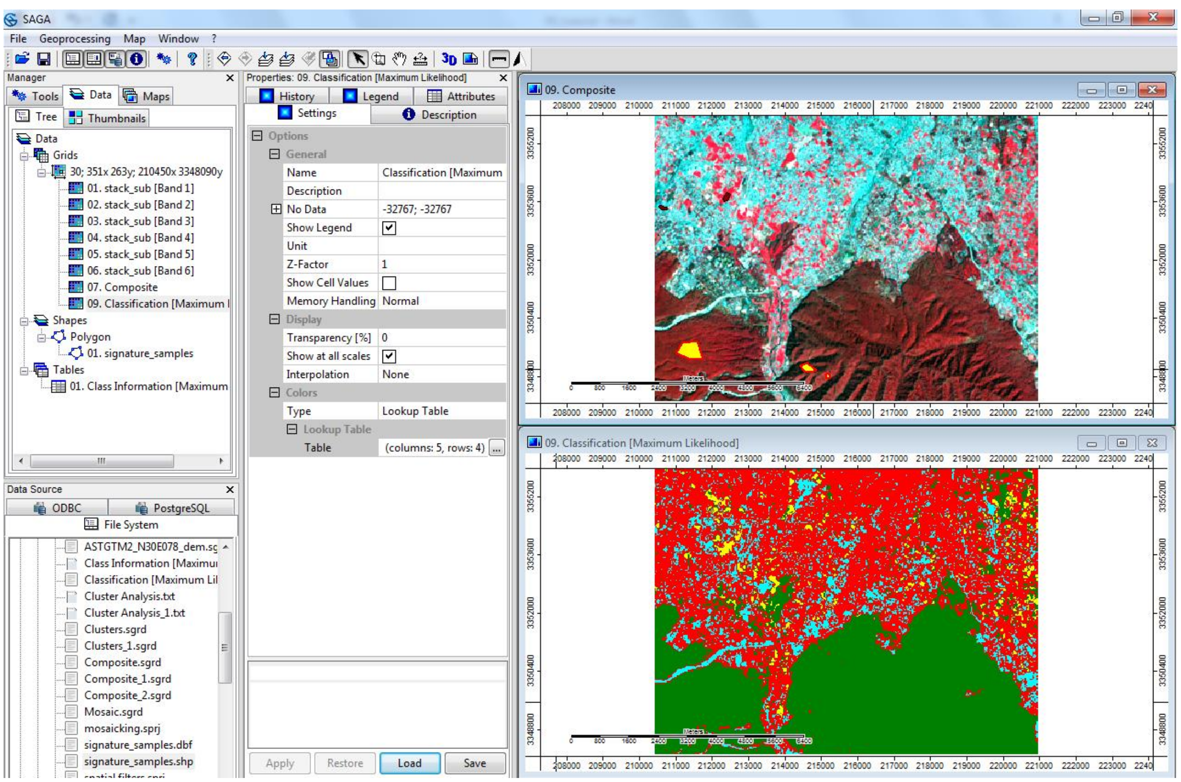


We can assign colors and class names via the lookup table. Select the image from the list and open the lookup table by clicking the button via the tab



The lookup table will open with 5 columns - COLOUR, NAME, DESCRIPTION, MINIIMUM, and MAXIMUM. Click on the color box and select a color from the palette or create your own. Click on 'Okay' and then 'Apply' in the tab.



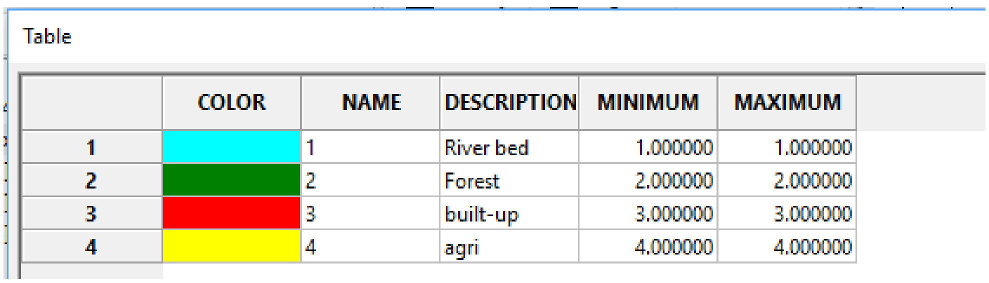


There may be parts of the image which are wrongly classified. This mostly happens if the signature of one class is similar to that of another class. This can be fixed by refining the signatures and run the classification again. For example, in the classification below, the built-up pixels have been wrongly classified as river bed. Compare the picture on bottom to the satellite image on the top. We may rectify this by creating signatures samples from these pixels and then classifying them as built-up.

Accuracy assessment

Load the classified image (Classification [Maximum Likelihood]) and the satellite data (stack_sub) as learnt in previous exercises. Open the satellite data in RGB composite in a new map window and classified image in another map window. Tile the two map windows vertically from Window→Tile Vertically.

Click on the classification image in data tab and change the 'colors' type option in the settings tab from graduated colors to look up table. Now check the look up table in the settings tab. It should resemble the following



Table

	COLOR	NAME	DESCRIPTION	MINIMUM	MAXIMUM
1		1	River bed	1.000000	1.000000
2		2	Forest	2.000000	2.000000
3		3	built-up	3.000000	3.000000
4		4	agri	4.000000	4.000000

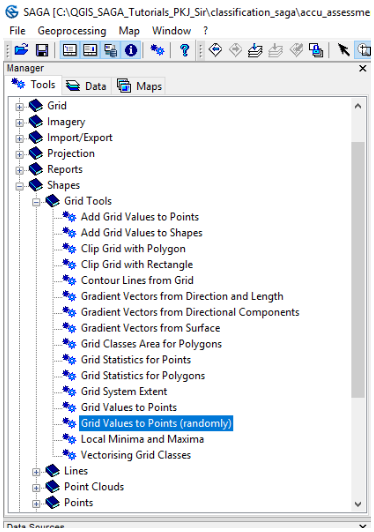
The classification image is classified into 4 classes.

Class	Class Name
1	Riverbed
2	Forest
3	Built-up
4	Agriculture

Accuracy assessment in SAGA GIS will involve four basic steps.

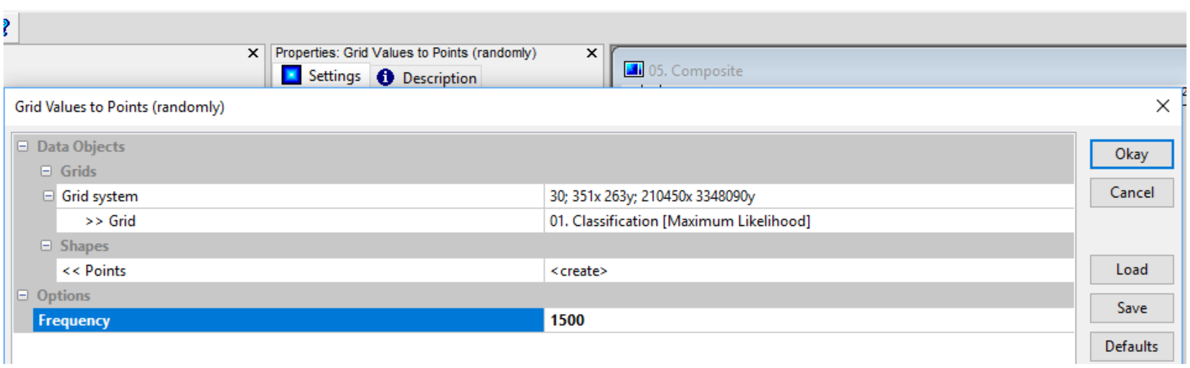
a) creating random points
b) extracting values of the classifies image at these randomly generated points
c) filling reference values of these points from the satellite image.
d) computing accuracy assessment parameters using confusion matrix

Go to Tools→Shapes→Grid Tools→ Grid value to points (randomly).

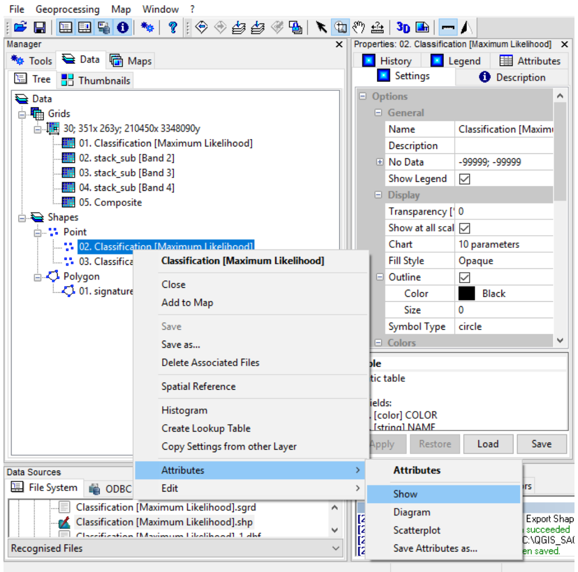


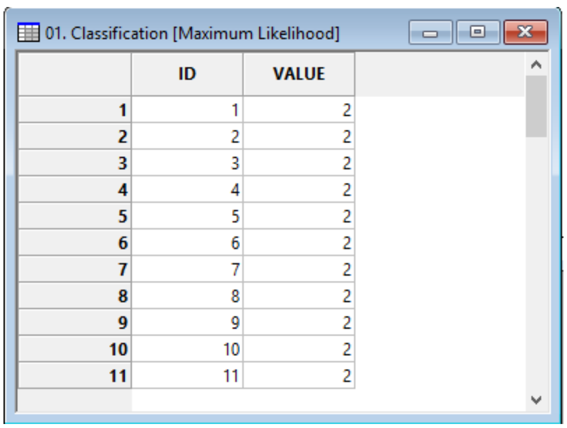
Fill in the parameters as shown below.

Grid should be your classified image, you can try playing with the frequency option, decreasing the frequency value will increase the number of points generated. A value of 1500 seemed optimum for the size of our data set and generated a point shapefile with 56 points.



Right click on the point shapefile in the data tab and open the attribute table as shown below

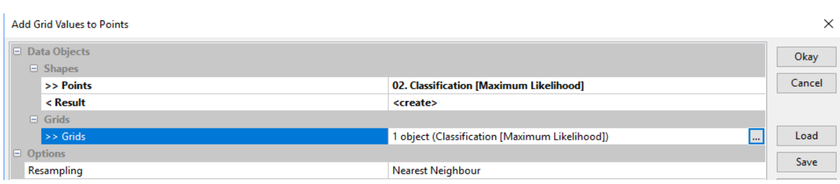




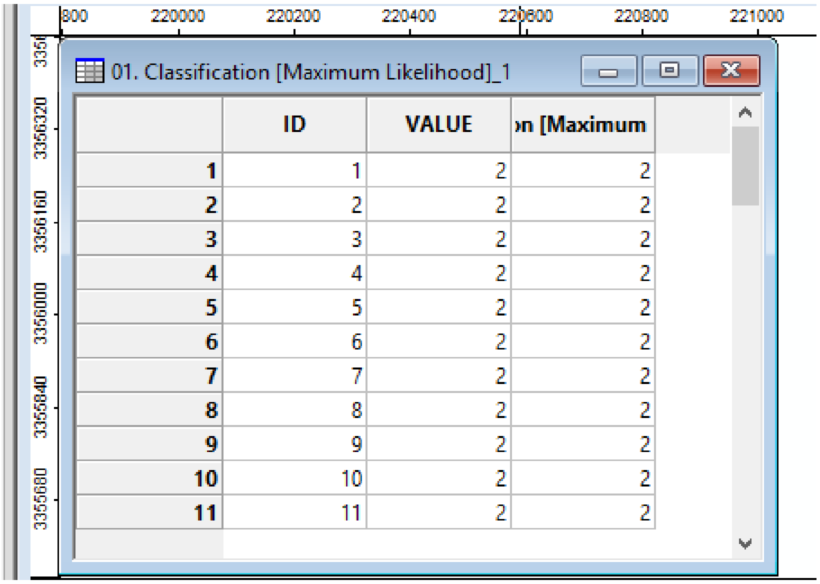
	ID	VALUE
1	1	2
2	2	2
3	3	2
4	4	2
5	5	2
6	6	2
7	7	2
8	8	2
9	9	2
10	10	2
11	11	2

Here value represents the class in which individual points are classified.

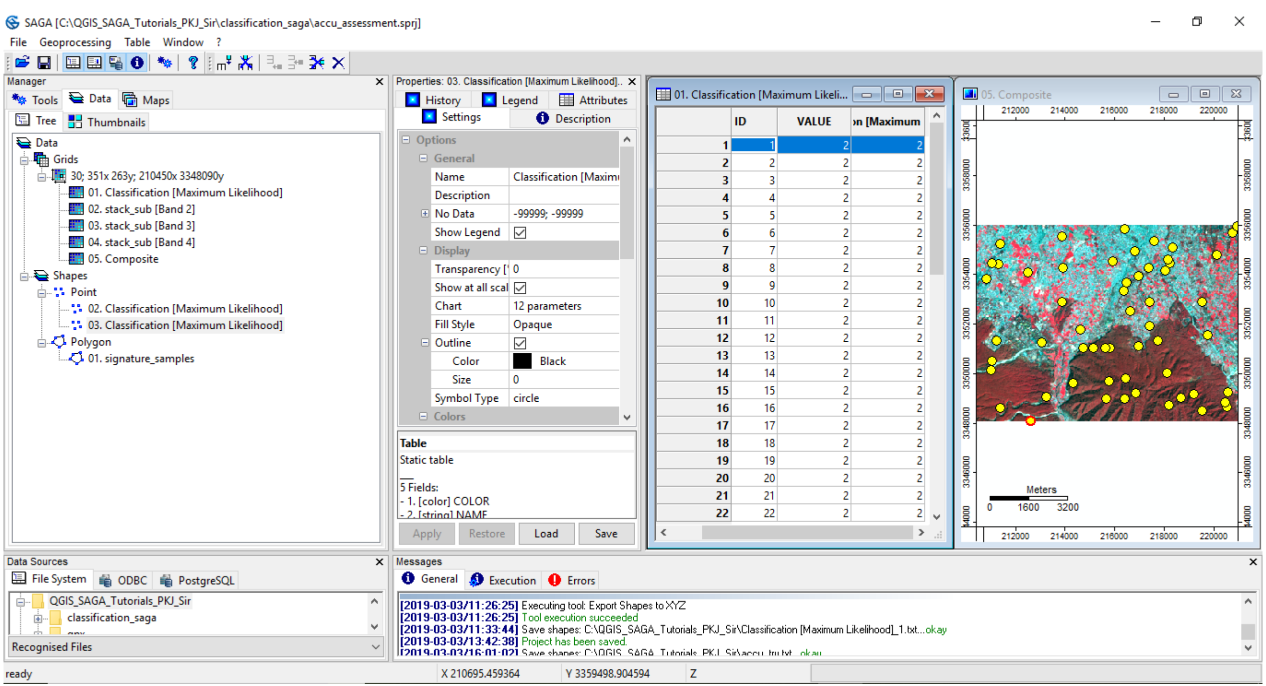
We need another column to fill in our reference values from the classified image. For this go to Tools→Shapes→Grid Tools→Add grid values to points



In the points, select point shapefile created in the previous step and grids is the classification image, choose rest of the options as displayed above and click okay. This will create another point shapefile. Open its attribute table by following the steps described earlier.

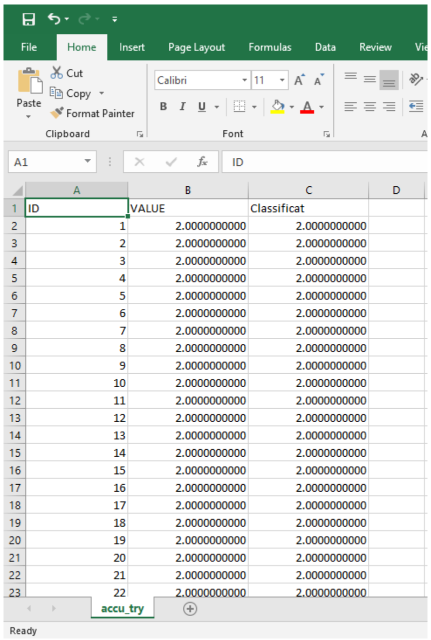


This will add another column to the table with values of the class of each point. Right click on this point shapefile and open it in the same map window as the satellite image by add to map option. In the attribute table of the point shapefile, double click on the first row. This will select the point with ID 1 in the map window. Zoom to that location and make a guess as to in which class this point should have been classified and fill the class number in column three. Repeat this for all the remaining points. Your final table will now contain class values in the "value" field and reference values in the "[Maximum" field. Close the attribute table.



Right click on the edited point shapefile and save as .txt file.

Open this .txt file in excel and it should look like this



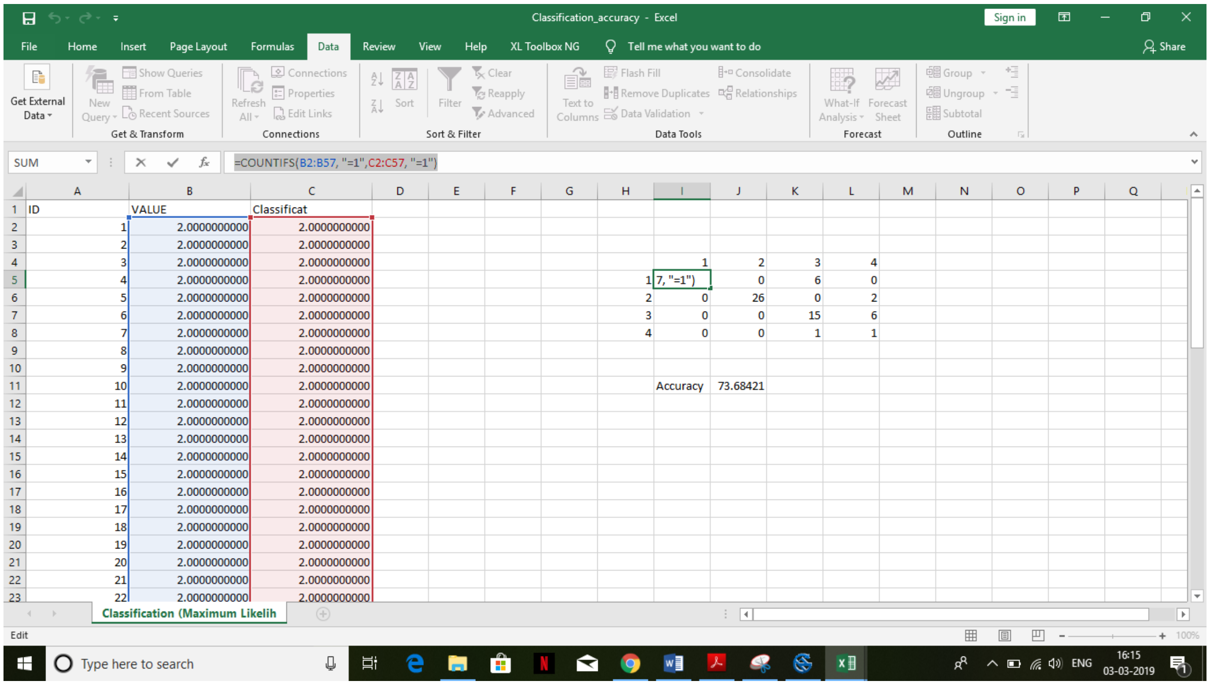
ID	VALUE	Classificat
1	2.0000000000	2.0000000000
2	2.0000000000	2.0000000000
3	2.0000000000	2.0000000000
4	2.0000000000	2.0000000000
5	2.0000000000	2.0000000000
6	2.0000000000	2.0000000000
7	2.0000000000	2.0000000000
8	2.0000000000	2.0000000000
9	2.0000000000	2.0000000000
10	2.0000000000	2.0000000000
11	2.0000000000	2.0000000000
12	2.0000000000	2.0000000000
13	2.0000000000	2.0000000000
14	2.0000000000	2.0000000000
15	2.0000000000	2.0000000000
16	2.0000000000	2.0000000000
17	2.0000000000	2.0000000000
18	2.0000000000	2.0000000000
19	2.0000000000	2.0000000000
20	2.0000000000	2.0000000000
21	2.0000000000	2.0000000000
22	2.0000000000	2.0000000000

Value column is your class value and classificat is your reference column.
We will now make the confusion matrix for the 4 classes.

	1	2	3	4
1				
2				
3				
4				

Make a matrix in your excel file as shown above.
Diagonal matrix elements represent the correctly classified pixels. For eg. 1,1 represent the number of testing samples which were classified as class 1 and also belong to class 1. Similarly,for 2,2 etc. Whereas matrix element 1,2 represent number of testing samples which are classified in class 1 but actually belong to class 2.
 We will now calculate these values using "countifs" function in excel.
In matrix element 1,1 , type this command. This will provide the number of vlaues in "value" field which is equal to '1' and is equal to '1' in the 'classificat' field also.

Meaning all the testing samples which were classified as 1 and actually belong to class 1. Here column B is the class value and C is the reference value.
=COUNTIFS(B2:B57, "=1",C2:C57, "=1")



In element 1, 2,
=COUNTIFS(B2:B57, "=1",C2:C57, "=2") Meaning all the testing samples which were classified as 1 and actually belong to class 2.
Similarly we compute the values for all matrix elements. Sum all the respective rows and columns. The total sum of rows and the total sum of columns will be equal to 56 which is the total number of testing samples collected. Here is an example.

	1	2	3	4	Row Total
1	0	0	6	0	6
2	0	26	0	2	28
3	0	0	15	6	21
4	0	0	1	1	2
Column Total	0	26	22	9	

Overall Accuracy= ((sum of all the diagonal elements*100)/ Total sum of all the elements)

This will range from 0 to 100%
Producer's Accuracy (PA) for each class = (Diagonal element or correctly classified samples/Column total for that class)*100

User's Accuracy (UA) for each class = (Diagonal element or correctly classified samples /Row total for that class)*100

For instance, in the example above, for class 2,
PA= (26/26)*100=100%
UA= (26/28)*100=92.85%

Similarly calculate for other classes also.
Compute the total number of agreements by summing the values in the diagonal cells of the table
Agreement (A)= 26+15+1 =42
Expected frequency for each class (E) = (row total*column total)/ total number of testing samples
Eg. For class 2, Expected frequency = (28*26)/56=13

Calculate sum of E for all the classes.

Kappa= (Sum of all the diagonal elements (A)- Sum of E for each class)/(Total number of testing samples-Sum of E for each class)

Calculate this yourself!!

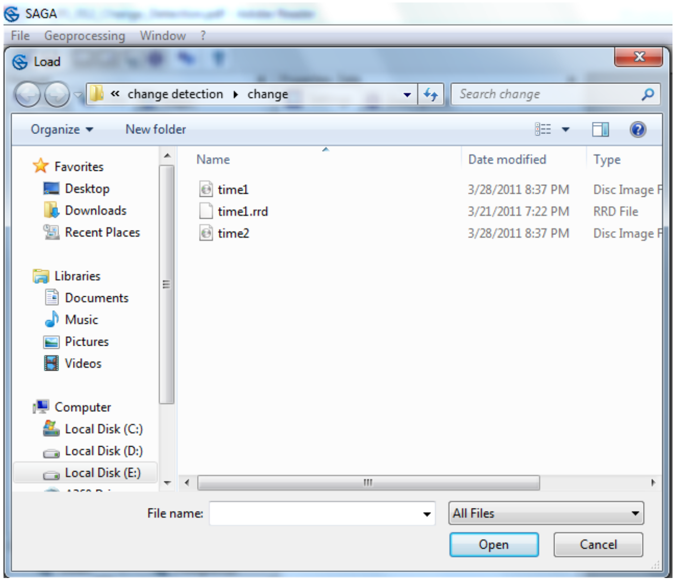
CHANGE DETECTION

Introduction

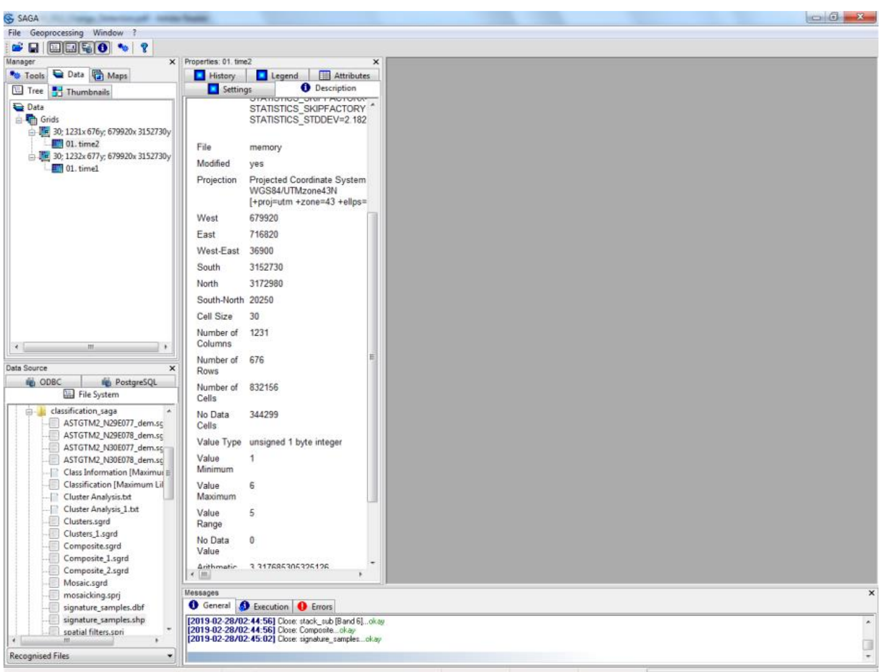
Change detection enables us to assess the gains and losses among various types of land use and land cover in a region over a period of time. Remote sensing data is widely used for change detection due its high temporal resolution, wide coverage and cost effectiveness over field surveys/inventories. Change detection can be used as diagnostic tool to understand the impact of anthropological effects on natural resources, which might further help us to prepare a sustainable planning measure to protect our environment. Change detection techniques are mainly of two types. The first one is spectral change detection, in this technique the unit of analysis is a pixel, a neighborhood, a multi temporal segment or a spectral class (Campbell & Wynne, 2011). One would require accurate radiometric, atmospheric and geometric corrections to be carried out before performing the spectral change detection. The second technique is post-classification change detection. It uses thematic maps (classified images) as inputs. It is a relatively easy and less accurate method compared to spectral change detection. In this tutorial we will learn how to perform post-classification change detection in SAGA.

In the supervised and unsupervised classification tutorial, we learnt how to create thematic maps from satellite images using different image classification techniques and how to assess their accuracy. These images serve as excellent visual guides to understanding the spatial distribution of the land use and land cover of a region. Furthermore, they can be used to calculate the actual spatial extent of different land classes at that point in time. However, a single land-use map may not be enough to identify areas where change is taking place. To see what changes have taken place to the landscape, it becomes necessary to have at least two land cover maps of a region at two points in time. Therefore, the procedure of 'Change Detection' utilizes two or more such thematic images belong to different periods to track the changes that have taken place in the study region over the length of that period. This allows us to assess which land classes are gained, losses and remained the same over the period of time.

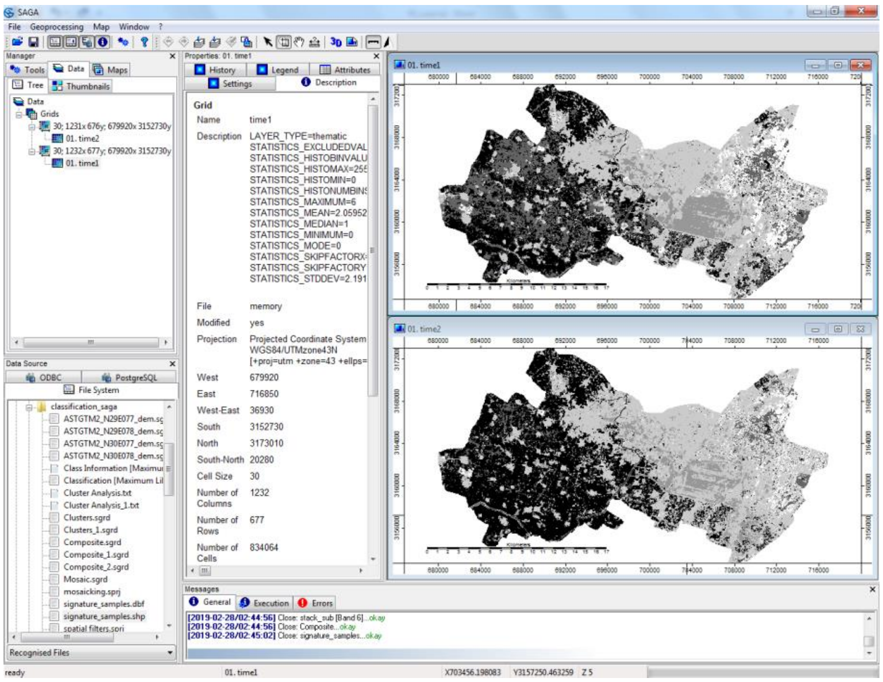
1. Import the thematic images in SAGA via the Load button. Navigate to the folder containing the tutorial data and change the file type to 'All Files'. Select the tiff files named 'time1' and 'time2', and click 'Open'.



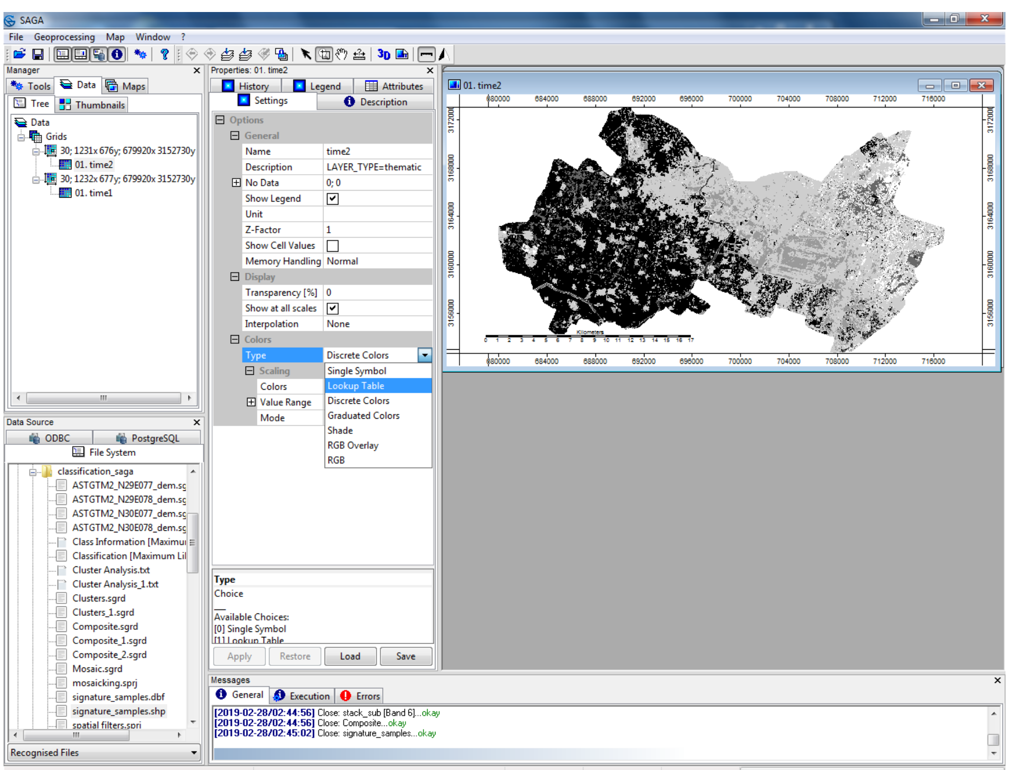
Select the image 'time1' in the list under tab section, and click on the tab on the right. This displays the metadata of the image file. You will see that the 'Value Type' is 'unsigned 1-byte integer' and the values range from 1 to 6, this means that there are 6 land classes in this image.

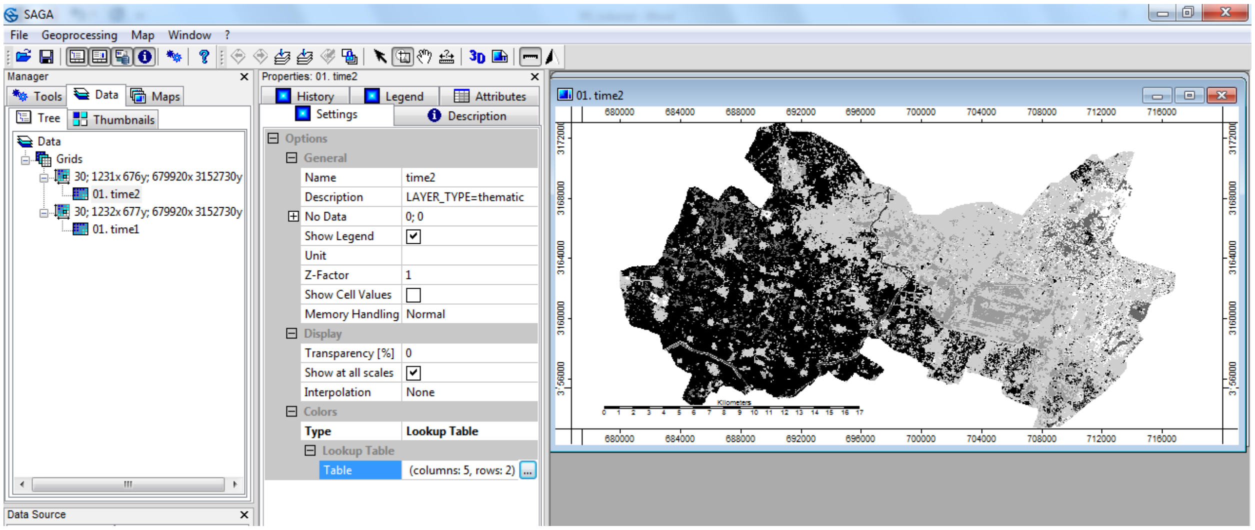


Double click on the images to open them. They will appear in shades of grey. This is because the class numbers are being treated as pixel DN values. However, that is not the case as this is a thematic image and each number represents a unique land class. We will use the lookup table that accompanies the .tif images to designate the appropriate class names.

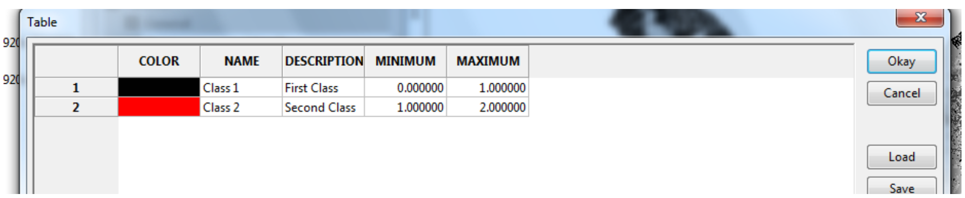


Click the tab and change the 'Colors' type from 'Graduated Color' to look up table.'

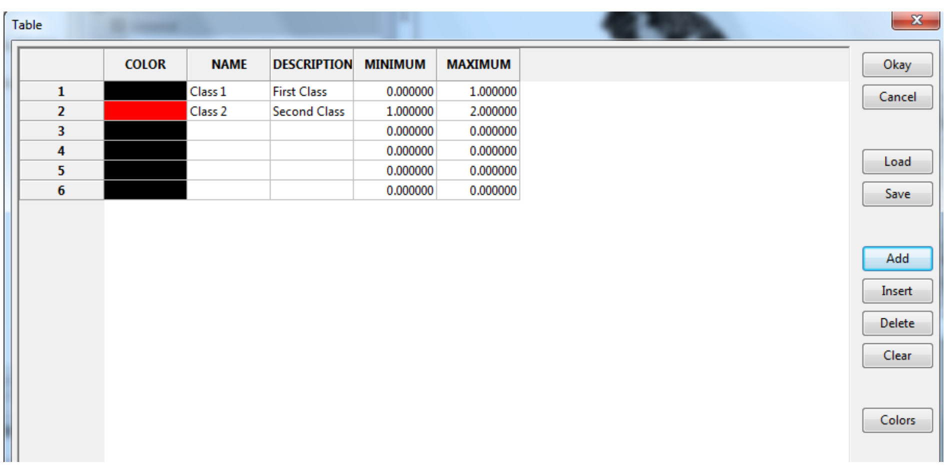




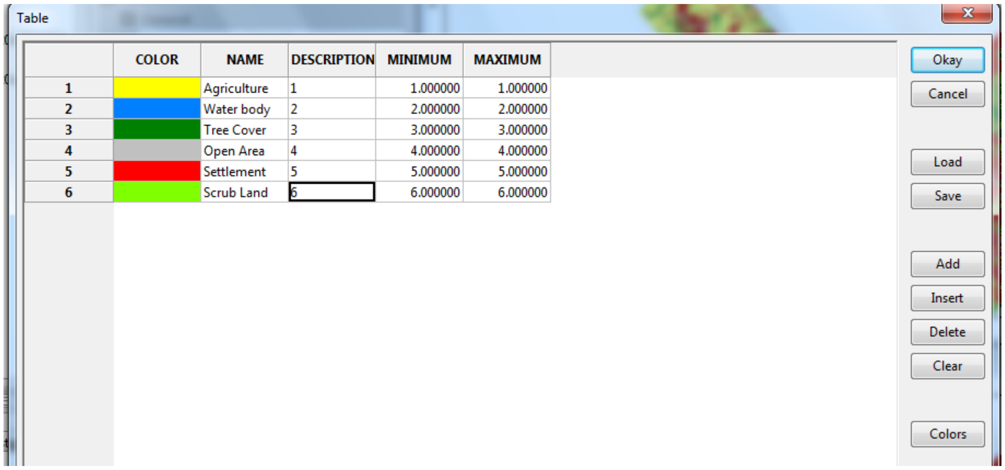
Click on table



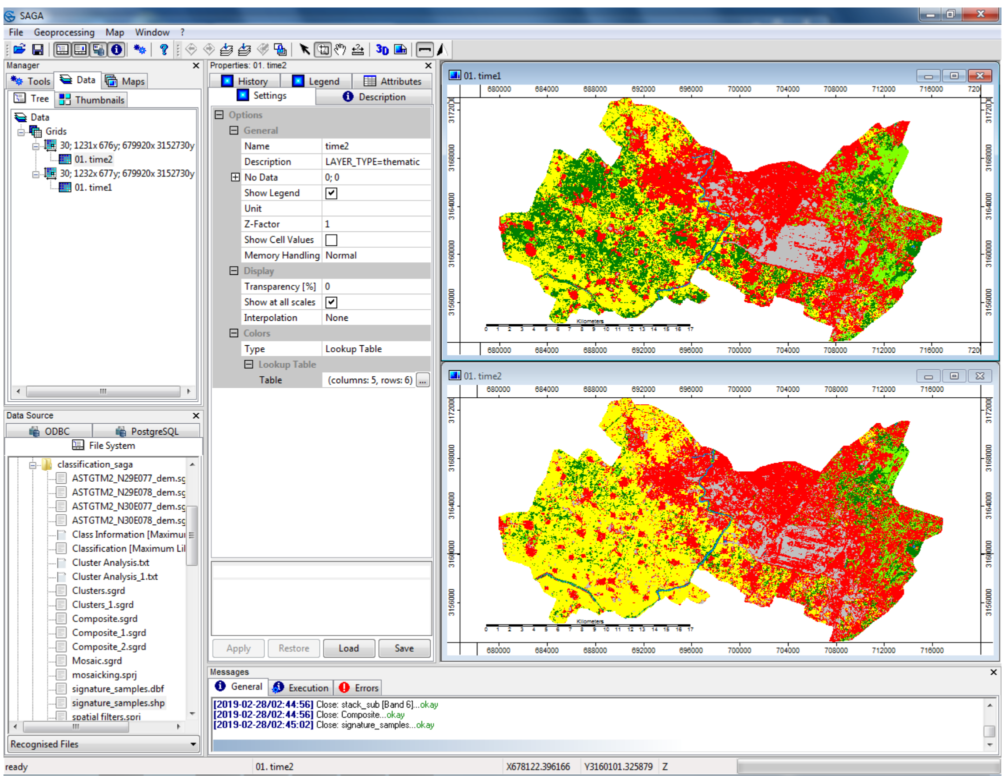
Click on add to make the number of classes 6



Now change minimum and maximum as follows

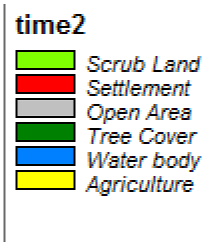


	COLOR	NAME	DESCRIPTION	MINIMUM	MAXIMUM
1		Agriculture	1	1.000000	1.000000
2		Water body	2	2.000000	2.000000
3		Tree Cover	3	3.000000	3.000000
4		Open Area	4	4.000000	4.000000
5		Settlement	5	5.000000	5.000000
6		Scrub Land	6	6.000000	6.000000

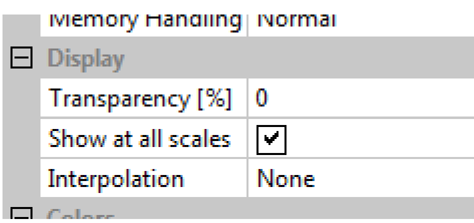


Look at the 

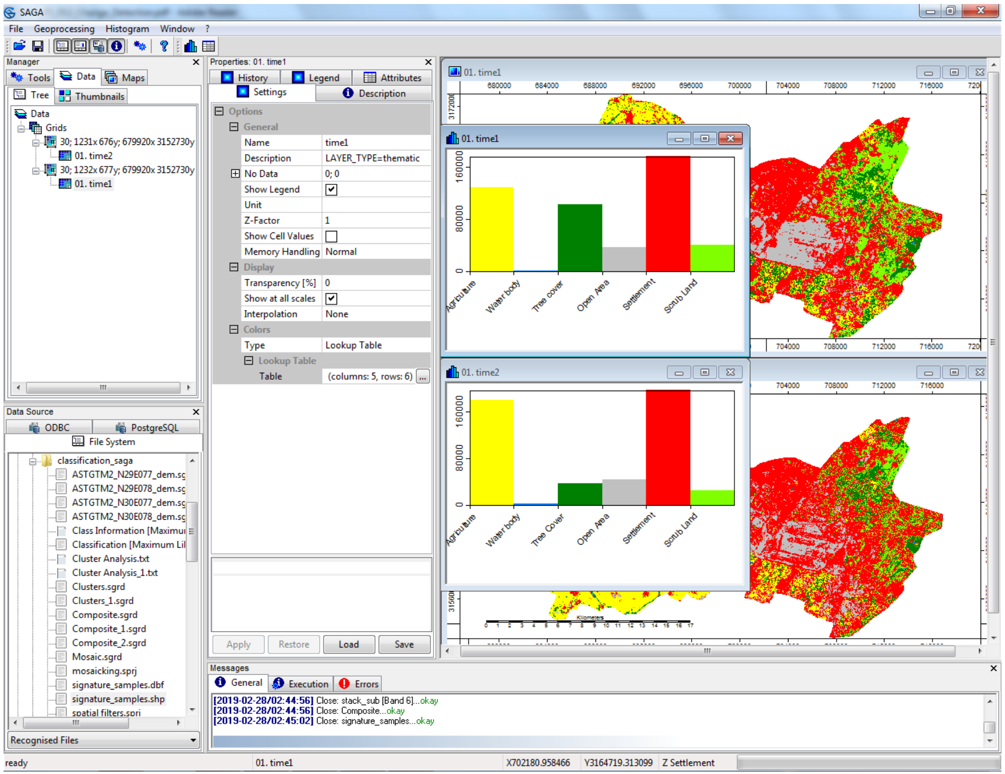
tab to see which land class each colour indicates. It will look like this:



Overlay the 'time2' image on the 'time1' image. Turn it on and off via the 'Maps' tabs by double-clicking on it. This way, we can visually gauge the gains or losses of the land classes over the decade. Or by turning on and off the " show at all scales" option in Display tab of Settings.



The advantage of a georeferenced map over an ordinary map is that spatial measurements can be carried out on them easily. Let us take a look at the distribution of classes in the map using a histogram (Go to the Data tab → select the Land use Map → Right-click → Histogram). This will create a histogram of the classes in the current image. Do this for both images and place them side by side.

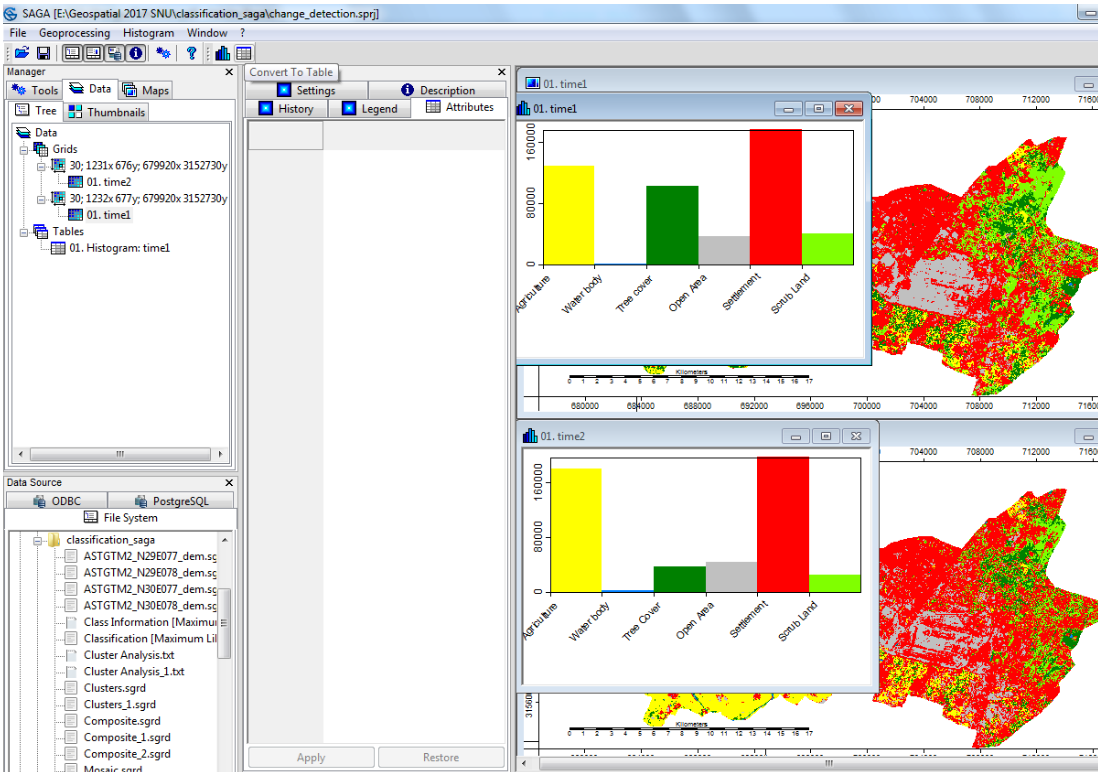


These histograms give us an idea of the relative distribution of classes within each image. However, to compare the land class distribution across images we need to have a single histogram containing all the class values. This can be done by converting the histograms into tables and then joining them.

Question 1: Which land class got converted to Grassland in the above region?
Question 2: Is there any other part of Pune that has expanded significantly?

These histograms give us an idea of the relative distribution of classes within each image. However, to compare the land class distribution across images we need to have a single histogram containing all the class values. This can be done by converting the histograms into tables and then joining them.

Select the 'Histogram map of time1' and then click on the 'Convert to Table' button in the toolbar above. Do this for the 'time2' window as well

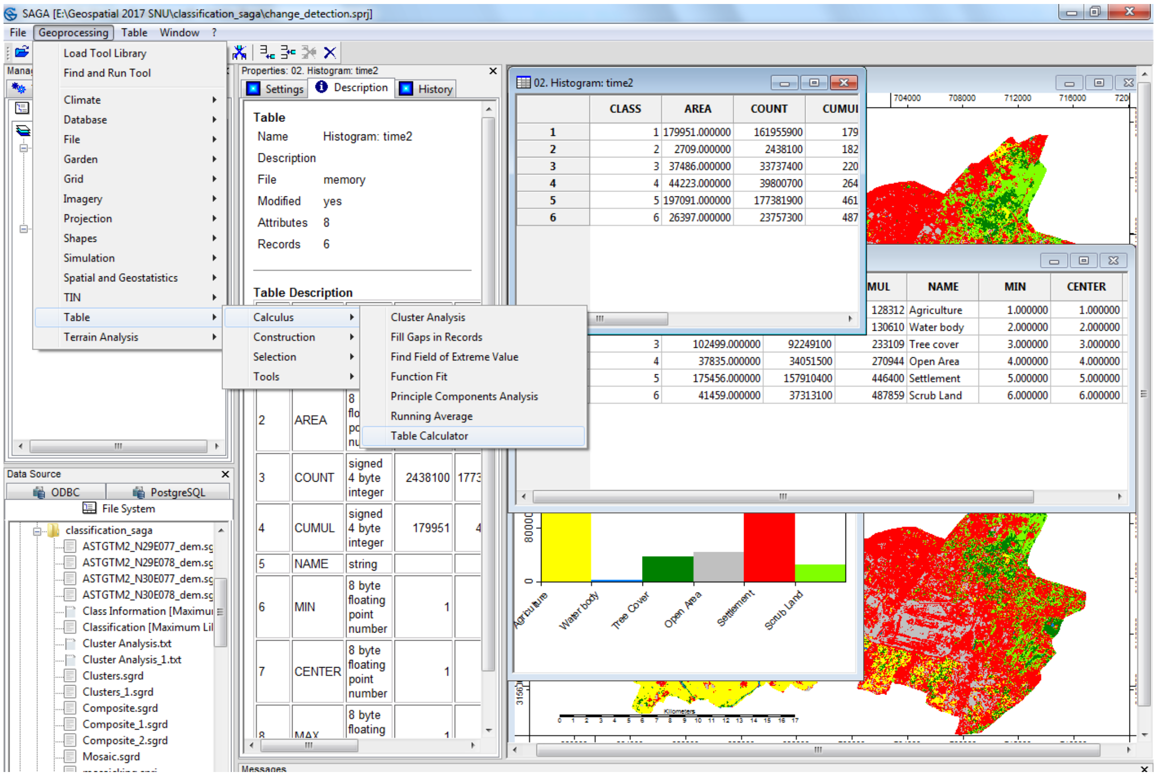


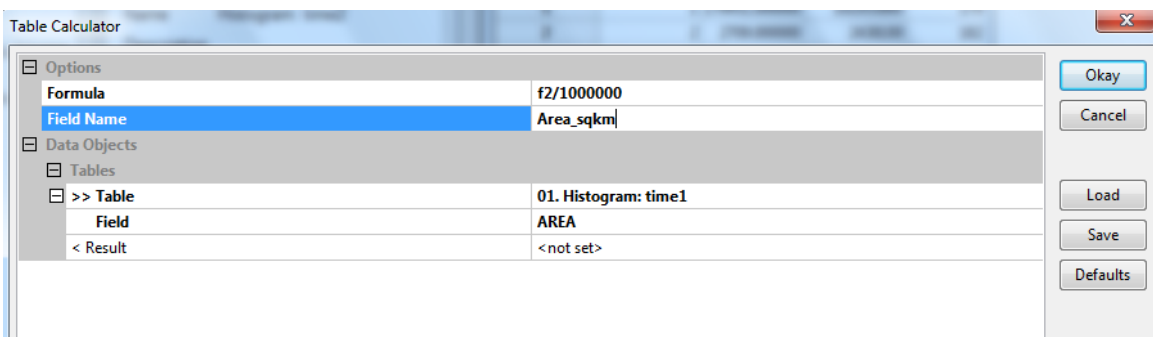
Two tables will appear in the Data tab list. Double-click on them to open. If the column is too small, expand it by holding left mouse bottom and dragging the border between two columns.

01. Histogram: time1

	CLASS	AREA	COUNT	CUMUL	NAME	MIN	CENTER
1	1	128312.000000	115480800	128312	Agriculture	1.000000	1.000000
2	2	2298.000000	2068200	130610	Water body	2.000000	2.000000
3	3	102499.000000	92249100	233109	Tree cover	3.000000	3.000000
4	4	37835.000000	34051500	270944	Open Area	4.000000	4.000000
5	5	175456.000000	157910400	446400	Settlement	5.000000	5.000000
6	6	41459.000000	37313100	487859	Scrub Land	6.000000	6.000000

The field titled 'AREA' describes the area of each land class in square metres. This becomes inconvenient at small scale maps (Those maps cover large areas, where we deal with hundreds or thousands of square kilometres). The conversion of area can be done by using 'table calculator tool' with a conversion parameter '1 m2=1/1,000,000 km2', open the table calculator (Geoprocessing → Table → Calculus → Field Calculator).





Set the window entries as shown above. They are explained below.

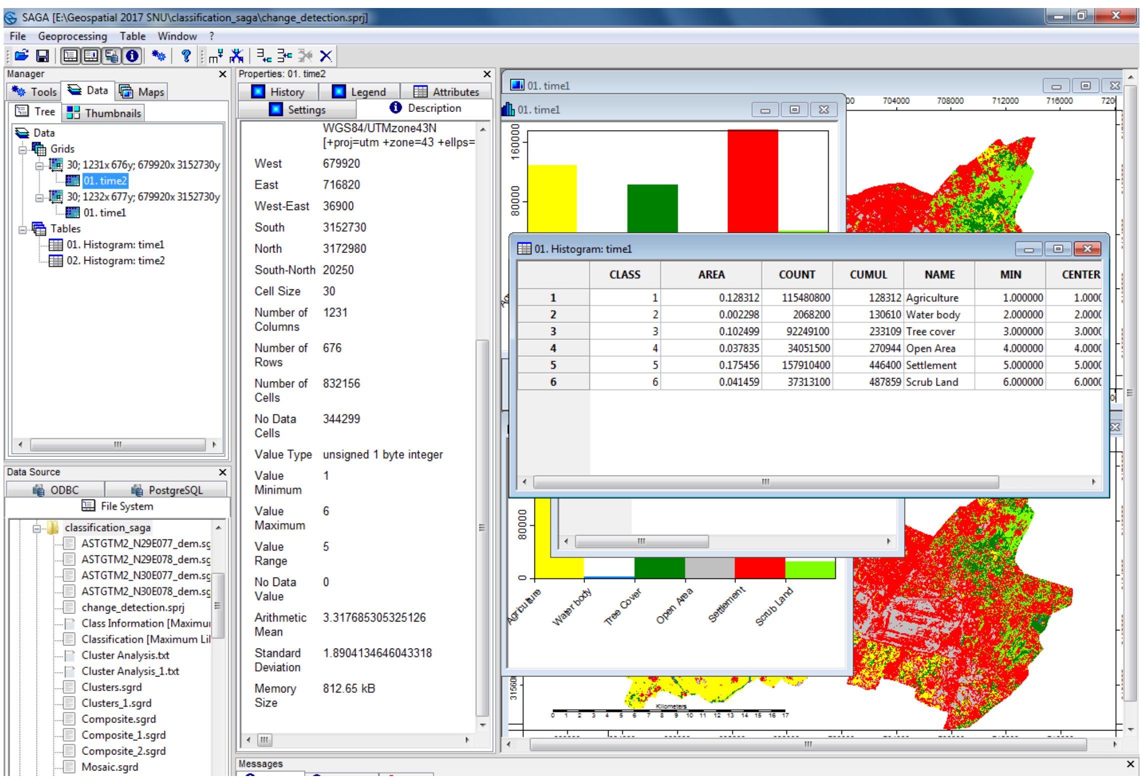
>>Table: This is the name of the table for which the calculation has to be done. From the dropdown menu select '01. Histogram: time1'.
Field Name: If the entry 'Field' is '[not set]' then this will the name of the new field. We will call the new field 'Area_sqkm', type it over field name.

Field: This decides which field the results will be placed in. Select one from the dropdown menu. If it is '[not set]' it will create a new field titled by the 'Field Name' entry. This time we will keep it as '[not set]'.

Formula: This is the calculation to be performed on 'AREA' field which is third on table (f1, f2, f3… are being the first, second, third…etc fields). Change the default formula to 'f2/1000000' since we are converting 'AREA' from square metres to square kilometres.

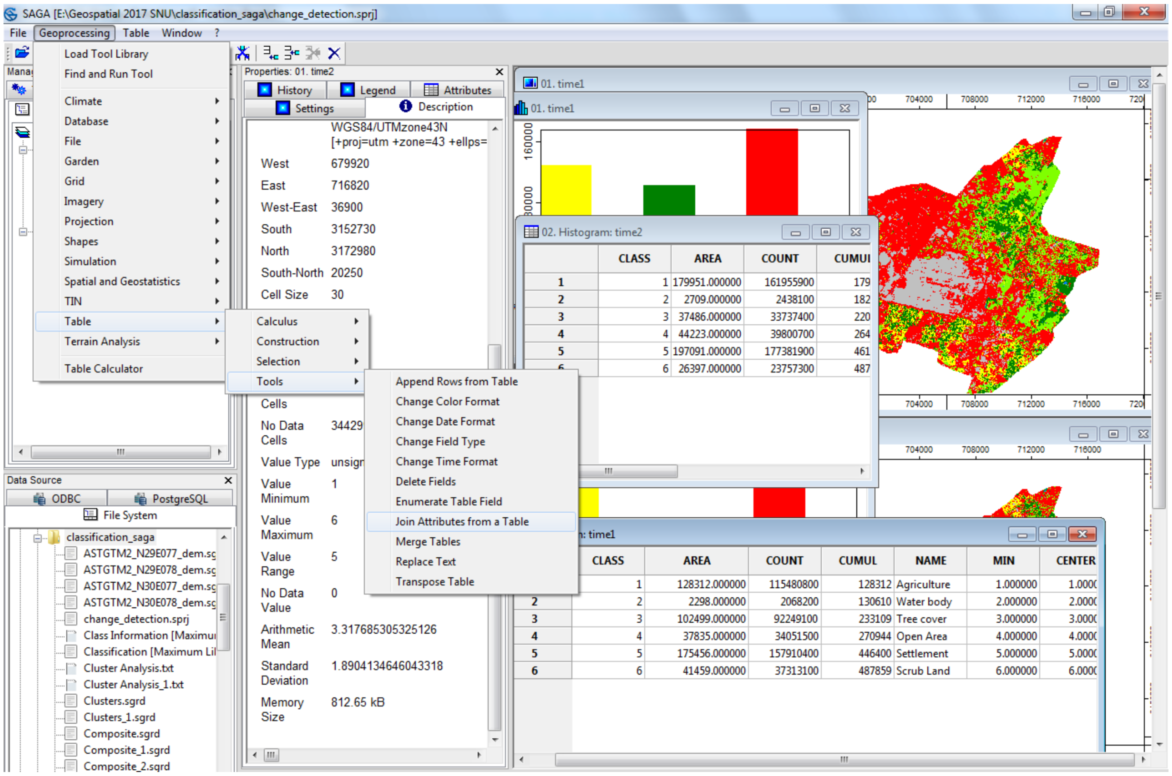
Result: This points to which table the result will be placed in. '[create]' will create a new table. Keep this as '[not set]' to append the result to the current table.
Now click on 'okay' to finish.

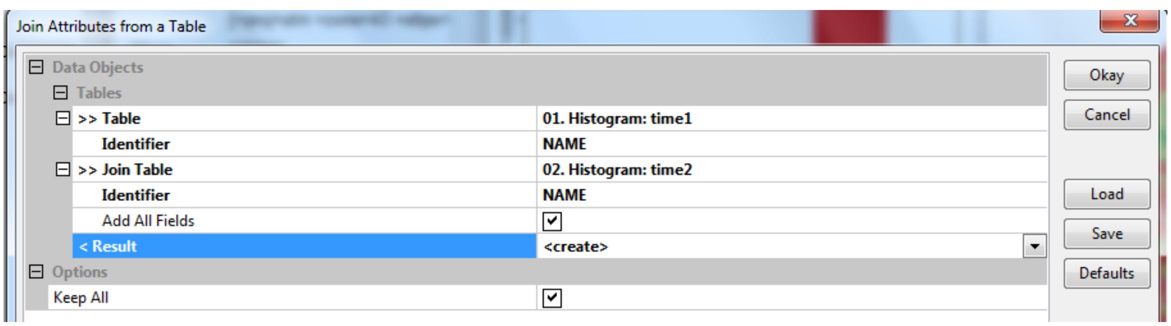
16. Open the table '01. Histogram: time1' again. The new field will be seen replacing the old one. Repeat the steps for the table '02. Histogram: time2'



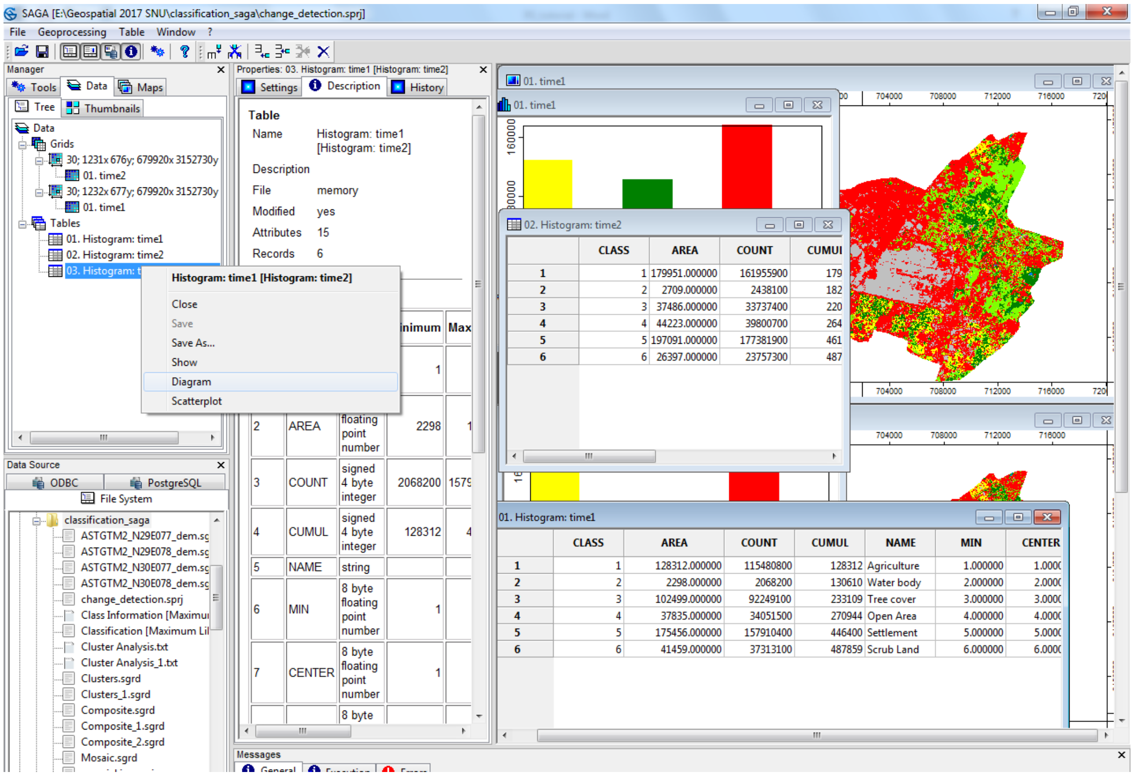
However, since our area is small, we will keep the area in sq km

We now open 'Geoprocessing → Tables → Tools → Join Attributes from a Table'. Set the 'Table 'entry as '01. Histogram: time1' and the 'Join Table' entry as '02. Histogram: time2'. The Identifiers are the fields to be used as the common link. Set them both to 'NAME'. To create a new table select '[create]' from the 'Result' dropdown menu. Now click on 'Okay'.

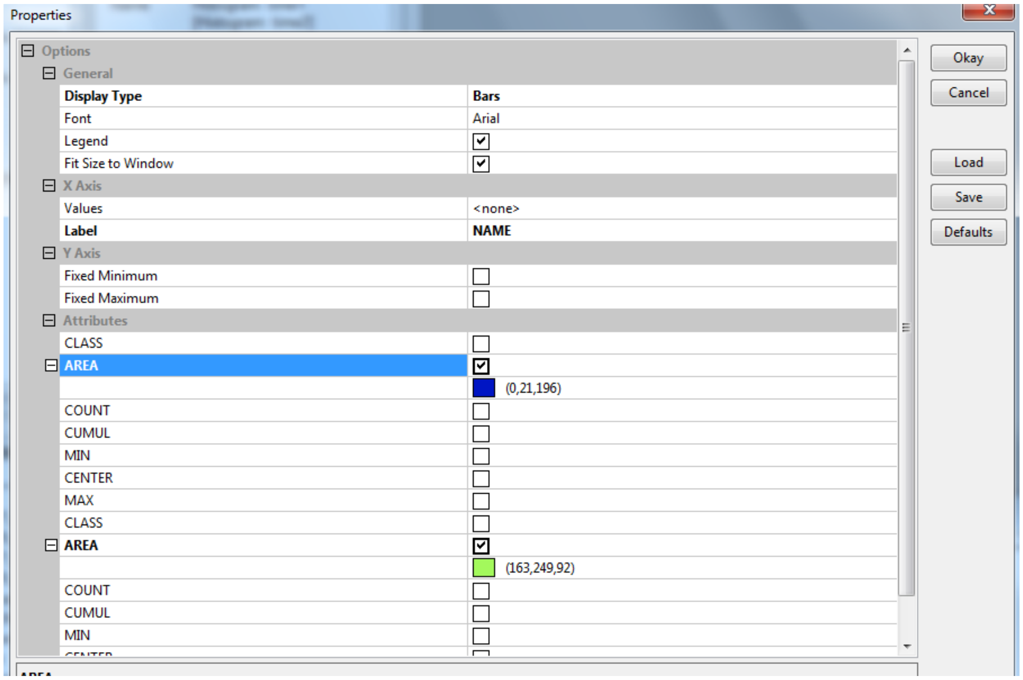


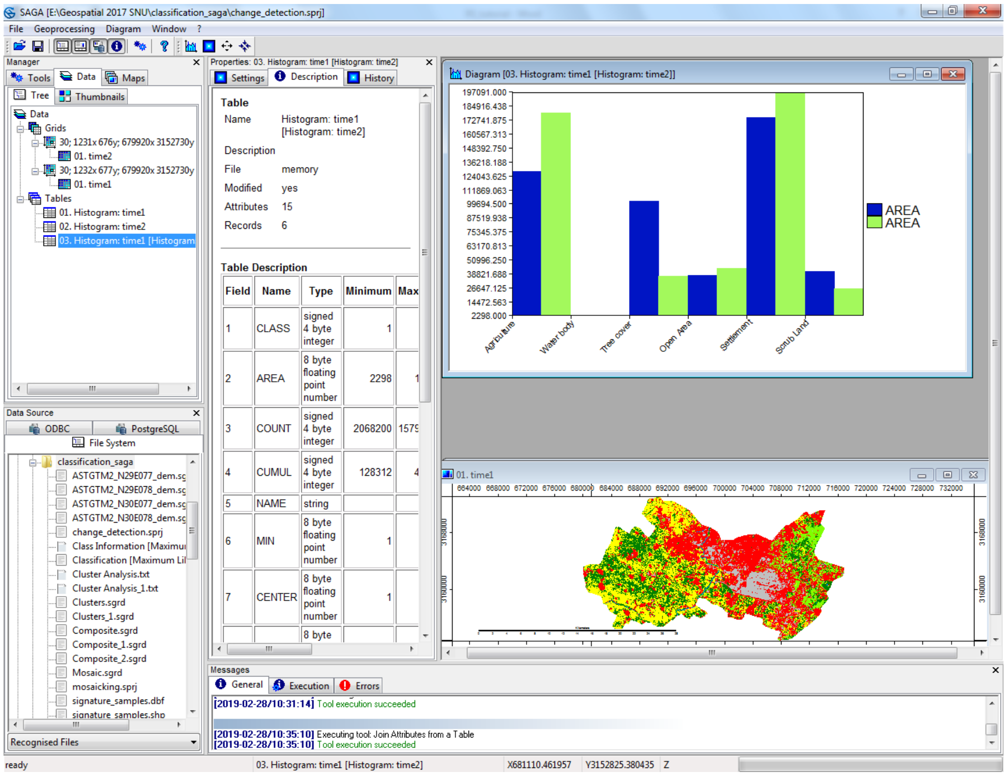


The resulting table will have fields from both tables. We can now create a histogram comparing the areas of the two images. Right-click on the table and select 'Diagram'.



In the Properties window, change the 'Display Type' to 'Bars' and the 'Label' value to 'NAME'. From the 'Attributes' section, check the options for 'Area (time1)' and 'Area (time2)'. You can change the colors if you like. Click 'Okay'. The resulting graph will look like below:





Here the histogram shows the increase or decrease in area of each class over a decade.
Question 3: Which class shows the highest increase?

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