

## Exercise 4b: Image classification and comparing images over time

### Lecture: Classification and Change Detection

**Description:** For this exercise we will use Landsat imagery to examine Cusco over time by classifying images and conducting a change analysis using images from 2000 and 2014.

**Objective:** Using Image Analysis in ArcGIS will provide students with hands-on techniques for working with remotely sensed data. In this exercise we will be focusing on detecting urban areas. In this exercise we are using a Landsat 7 image from July 1, 2000 and a Landsat 8 image from Aug 9, 2014.

Classifying images for change detection is one of the key tools of a geospatial scientist.

**Skills:** imagery interpretation and classification,

**Data:** Landsat 7 image, July 1, 2000; Landsat 8 image, Aug 9, 2014; 30 m resolution (for most bands)

Landsat represents the world's longest continuously acquired collection of space-based moderate-resolution land remote sensing data. Four decades of imagery provides a unique resource for those who work in agriculture, geology, forestry, regional planning, education, mapping, and global change research. Landsat images are also invaluable for emergency response and disaster relief.

([http://landsat.usgs.gov/about\\_project\\_descriptions.php](http://landsat.usgs.gov/about_project_descriptions.php))

Where you can download: <http://earthexplorer.usgs.gov/>

<http://landsatlook.usgs.gov/>

Guide to downloading Landsat data using USGS Earth Explorer:

<http://earthobservatory.nasa.gov/blogs/elegantfigures/2013/05/31/a-quick-guide-to-earth-explorer-for-landsat-8/>

Landsat Resources: Landsat images are composed of spectral bands that measure reflected energy as detected from the electromagnetic spectrum. We can use the different spectral signatures of an image to assess different characteristics of the landscape.

Read about these different band designations at these sites:

Band designations: [http://landsat.usgs.gov/best\\_spectral\\_bands\\_to\\_use.php](http://landsat.usgs.gov/best_spectral_bands_to_use.php)

Differences in band designations between Landsat 7 and Landsat 8:

[http://landsat.usgs.gov/L8\\_band\\_combos.php](http://landsat.usgs.gov/L8_band_combos.php)

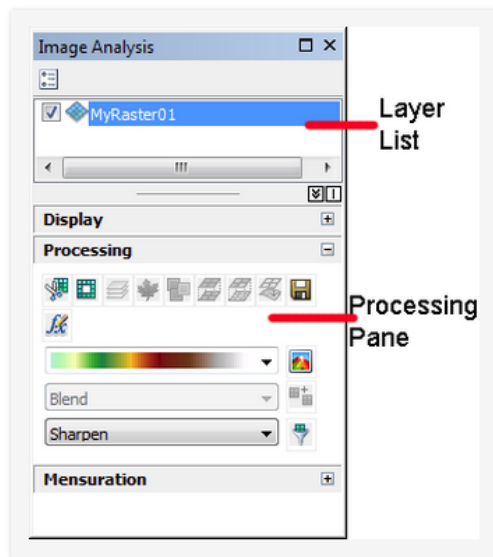
- Set up a folder for Exercise 4b.

We will use the image processing tools in ArcGIS for this exercise. The **Image Analysis window** supports the analysis and exploitation of image and raster data in ArcMap with a collection of commonly used display capabilities, processes, and measurement tools.

**Read** *What is the Image Analysis Window* in ArcGIS Help:

<http://resources.arcgis.com/en/help/main/10.1/index.html#/009t000001tm000000>.

- 1) Open your Image Analysis window (**Windows → Image Analysis**)

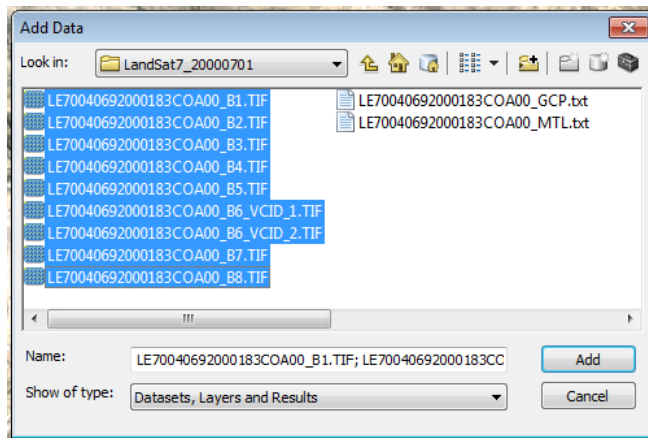


The **Image Analysis window** should pop up.

The Processing buttons are defined below:

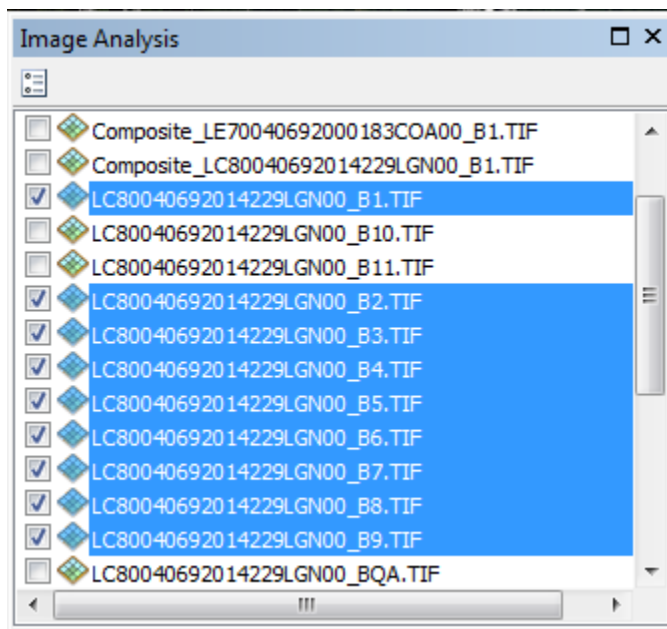
Button	Name	Conditions
	Clip	Enabled when 1 or more layers are selected.
	Mask	Enabled when 1 or more layers are selected.
	Composite Bands	Enabled when 2 or more layers are selected.
	NDVI	Enabled when a multiple band layer is selected, or 2 single band layers.
	Colormap To RGB	Enabled when a colormap layer is selected.
	Difference	Enabled when 2 layers with the same number of bands are selected.
	Pan-sharpening	Enabled when a multiple band layer and a single band layers are selected.
	Orthorectify	Enabled when a layer with rational polynomial coefficients and a single band (DEM) layer are selected.
	Export	Enabled when any one layer is selected.
	Function Editor	Enabled when any one layer is selected.
	Shaded Relief	Enabled when 1 or more single band rasters are selected.
	Mosaic	Enabled when 2 layers with the same number of bands are selected.
	Filter	Enabled when 1 or more layers are selected.

- 2) **Load the Landsat imagery to ArcGIS.** Each scene has a layer for the multiple bands. Load all of the bands. **Create pyramids as well.** Pyramids allows the raster image to load faster and enhance display performance and visual quality.



*You will see all of the separate bands in the Table of Contents, and you will only be able to see one at a time for now. We will use the Image Analysis Window to combine different bands together into composite images.*

- 3) **In the Image Analysis window, select all the bands for each Landsat image. Then click on the Composite Bands button to make a composite layer.**  
(Tip: for Landsat 8 you must select only bands 1-9 to avoid an error.)

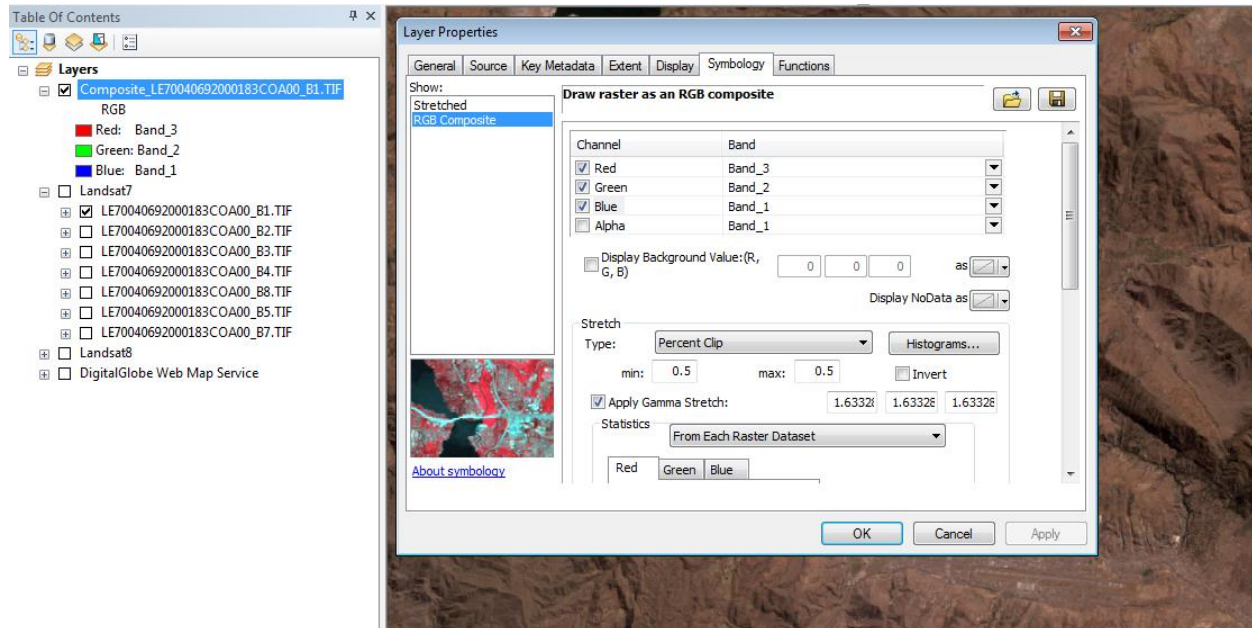


*You should now see a new temporary composite layer in your Table of Contents. This layer consists of all of the bands collected in the Landsat image and you can specify which three bands are represented by Red, Green and Blue channels.*

- 4) In the **Properties** of your composite layer **adjust the bands to make sure the Red, Green, and Blue channels are reading from the correct Landsat band.**

The Landsat 7 bands for Natural Color are: Red = Band 3; Green = Band 2; Blue = Band 1

The Landsat 8 bands for Natural Color are: Red = Band 4; Green = Band 3; Blue = Band 2

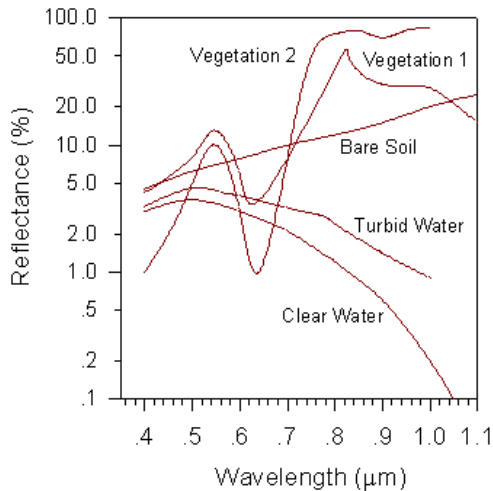


- 5) **Experiment with different band combinations.**

A common question is what spectral bands should be used for a study area. Each Landsat band represents a different portion of the electromagnetic spectrum, and certain bands and band combinations are better suited for identifying particular types of surface materials.

The Red, Green, Blue band combination is the closest to true color that we can get from a Landsat image.

The Infrared, Red, Green band combination produces what is called a 'false-color composite' and is often used to detect vegetation. The human eye can't naturally see light in the infrared spectrum, but here the red channel is representing the infrared signal the Landsat sensor is picking up. Vegetation has a high reflectance value in the infrared spectrum and shows up brightly.



**Figure 1 Read about Spectral Reflectance Signature:**

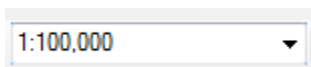
[http://www.crisp.nus.edu.sg/~research/tutorial/optical.htm#spectral\\_signature](http://www.crisp.nus.edu.sg/~research/tutorial/optical.htm#spectral_signature)

For Landsat 7: Band 7 (Red), Band 4 (Green), Band 3 (Blue) can work well for detecting urban areas. Band 7 (MID or SWIR spectrum) can pick up minerals and human-made materials well, so you can expect them to look red or pinkish.

**NOTE:** the bands in Landsat 7 are different than Landsat 8. Look into the source materials to figure out what bands you need to choose to make both composite images be comparable to each other. Check out this: <http://blogs.esri.com/esri/arcgis/2013/07/24/band-combinations-for-landsat-8/> You can compare the bands between Landsat 7 and Landsat 8 and determine what would work best to use to compare between images. (**HINT:** Try Red = 7; Green = 5; Blue = 4)

- **Zoom** into Cusco on the Landsat 7 image: Latitude: 13°32'S; Longitude: 71°56'W  
*Do you remember how to set the Data Frame properties and change the units in the lower right corner of the Data Frame window?*

6) **Clip extent to narrow the area of classification. Set the scale to: 1:100,000.**



**In the Image Analysis window select both Landsat layers then click on the Clip button on the Image Analysis window's Processing section.** It will create new temporary clip layers for both images.

7) **Perform Supervised classification on both images to detect urban areas**

**Resource:** Links to Remote Sensing tutorials are provided at the end of the exercise, in particular check out videos 19a and 19b.)

**NOTE: Before you do this, you need to think about what classes of landcover you want to identify.** Discuss with your team the different land cover classes you want to use. Assess the image to see what classes are visible and that you are able to classify. The resolution of the data will determine how refined you can make your classification system. For example, you might want to use water bodies, vegetation, urban area, agriculture, etc....

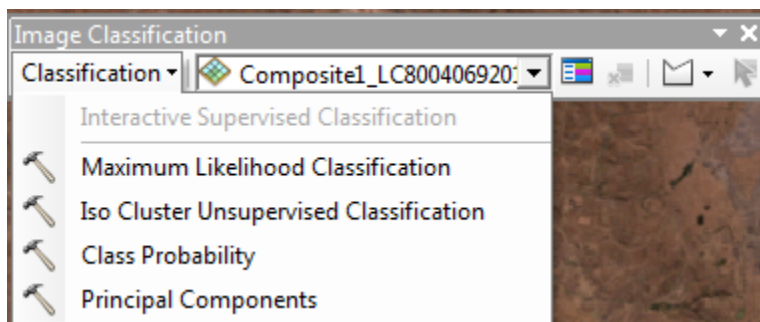


Figure 2 The Image Classification toolbar


**Read** An Overview of the Image Classification toolbar in ArcGIS Help:

[http://resources.arcgis.com/en/help/main/10.1/index.html#/An overview of the Image Classification toolbar/00nv00000008000000/](http://resources.arcgis.com/en/help/main/10.1/index.html#/An%20overview%20of%20the%20Image%20Classification%20toolbar/00nv00000008000000/)

*Supervised classification is the essential tool used to classify remotely sensed imagery. Using this method the analyst creates training samples that identify groups of pixels representing particular classes or known land cover categories. Then the classifier is used to attach labels to all of the image pixels according to the trained parameters. The most commonly used supervised classification is maximum likelihood classification (MLC). Maximum likelihood classification is based on statistics (mean, variance/covariance) to determine how likely a pixel will fall into a particular class.*

a) Turn on the **Image Classification** toolbar. Right click in the menu bar and the tools dropdown will appear. Check **Image Classification**.

Make sure the correct clipped composite layer is selected as your image classification layer on the Image Classification toolbar.

b) In the Image Classification toolbar click on the Training Sample Manager button . This is where your training samples will show up. You need to **create a training sample for all the different classes that show up on your image.** Now click on the 'Draw Polygon' button in the Image Classification toolbar and start drawing your training samples.

c) In the classification drop-down menu on the Image Classification toolbar, **select Interactive Supervised Classification**.

Read *Interactive Supervised Classification tool* in ArcGIS Help:

[http://resources.arcgis.com/en/help/main/10.1/index.html#/Interactive\\_Supervised\\_Classification\\_tool/00nv0000000z000000/](http://resources.arcgis.com/en/help/main/10.1/index.html#/Interactive_Supervised_Classification_tool/00nv0000000z000000/). The **Interactive Supervised Classification** tool works the same as the **Maximum Likelihood Classification** tool with default parameters.

*Supervised classification can be an iterative process where initial results can be evaluated to create better training samples.*

d) *How did your initial results turn out? Can you improve on them?* **Try adding or subtracting training samples and re-running Interactive Supervised Classification.**

- You can do this by removing the polygon from the Training Sample Manager list.


**Try adjusting the transparency of the classification and see if it helps you visualize the results.**

- You can do this by **right clicking** on the **Classification Composite name**, select **Properties/Display**. Set **Transparency** to **50%**.

If possible load high-resolution imagery from 2014 and see if this can help you refine your training samples.

*8) We want to compare both images and calculate the differences. To do this we will do Map Algebra. Examine the tables for the two Classified Clipped Composite images (Right click – Open Attribute Table). We have unique classification for our pixels into different land cover classes. Now we want to re-classify the rasters to have the pixels store values indicating only two values: if there is urban area or no urban area. Then we will be able to use Map Algebra subtract pixels from each other and calculate differences.*

a) We are interested in classifying urban change so we want to re-classify our rasters to include one class representing the urban areas and another class representing everything else.

b) **Open ArcToolbox**  **and go to Spatial Analyst Tools → Reclass → Reclassify.** **Select the Landsat 8 clipped classified composite as your input, select the classification Reclass field: Class Name, and click on the 'Add Entries' button. Enter new values so you just have '2' for urban, '0' for the other classes, and keep 'NoData' for the 'NoData' categories. BE SURE TO HIT ENTER after each entry.** **Give your Reclassed Image a meaningful name.**

Reclass field

Class\_name

Reclassification

Old values	New values
urban	2
vegetation	0
terrain	0
rough terrain	0
clouds	0
terrain3	0
terrain4	0
NoData	NoData

- c) Do the same thing as the previous step for the Landsat 7 clipped classified composite except for the new values input '1' for urban, '0' for the other classes, and keep 'NoData' for the 'NoData' categories.

*Think about when you subtract the Landsat 7 image from the Landsat 8 image what the pixel values will range from. What will each pixel class mean?*

- d) Open ArcToolbox and go to Spatial Analyst Tools → Map Algebra → Raster Calculator.

Map Algebra expression

Layers and variables

- ◆ rastercalc7
- ◆ Landsat 7 image
- ◆ Landsat 8 image
- ◆ Classification\_Clip\_Composite\_LC80040692014229LGN
- ◆ Classification\_Clip\_Composite1\_LE70040692000183CO
- ◆ Reclass\_Landsat7

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"Landsat 8 image" - "Landsat 7 image"

**Subtract the Landsat 7 image from the Landsat 8 image and click OK.** You should see a new raster with your results. There are four classes.

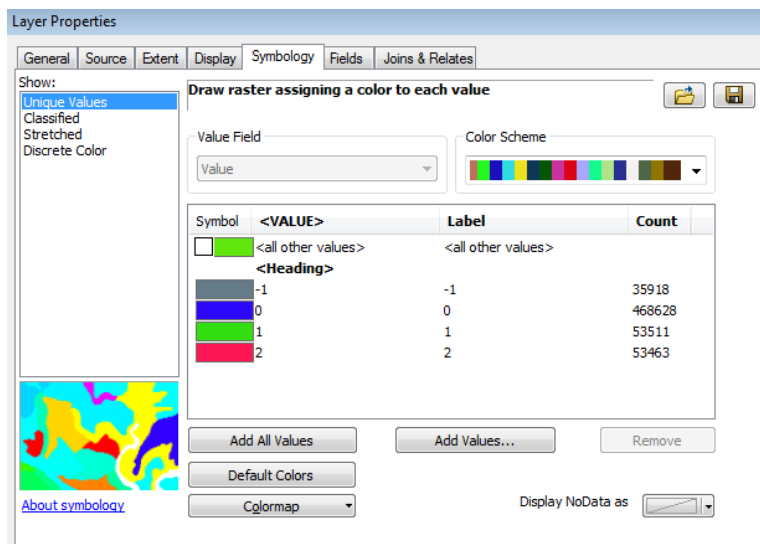
The value '2' represents new urban growth.

The value '1' represents existing urban areas.

The value '0' represents non-urban areas which haven't changed

The value '-1' values represent areas where urban areas have disappeared.





**Calculate percentage change in urban pixels between the two dates. Right-click on your layer and click on the Symbolism tab.** You are able to see each class and the count of the pixels for each class.

Estimate the urban growth in Cusco from 2000 to 2014. Then discuss and compare results with your neighbors.

#### Calculate Percent Change:

$((\text{new growth} - \text{disappeared urban areas}) / \text{existing urban areas}) * 100 = \text{percentage change}$

To get percent urban growth, subtract the pixel count of the urban areas that disappeared (-1) from the pixel count of the urban growth areas (2) and add the result to the pixel count representing the original urban area (1).

Ex:

$$((53,462 - 35,918) / 53,511) * 100 = 32\%$$

#### Calculate Area:

You could also calculate the area of urban change. *How would you do this? What is the area of each cell? How many cells do you have of new urban area? What is the area in hectares?*

#### Challenge Activities: (Choose one)

- Perform change detection between Landsat 8 images from 2013 and 2015
- Perform unsupervised classification in the first exercise and compare with your supervised classification results.

**Resources –****Online Videos:**

Remote Sensing in ArcGIS Tutorial 19a: Supervised classification of Landsat Imagery

([https://www.youtube.com/watch?v=\\_EBIOeybWI4](https://www.youtube.com/watch?v=_EBIOeybWI4))

Remote Sensing in ArcGIS Tutorial 19b. Supervised Classification of Landsat Imagery

(<https://www.youtube.com/watch?v=IfjWNYJ1LA>)

**Other materials:**

Remote Sensing in an ArcMap Environment:

[http://virginiaview.cnre.vt.edu/tutorial/Chapter\\_12\\_Band%20Combinations%20Using%20Landsat%20Imagery.pdf](http://virginiaview.cnre.vt.edu/tutorial/Chapter_12_Band%20Combinations%20Using%20Landsat%20Imagery.pdf)

How Landsat Images are Made: [http://landsat.gsfc.nasa.gov/pdf\\_archive/How2make.pdf](http://landsat.gsfc.nasa.gov/pdf_archive/How2make.pdf)