University of Oregon - GEOG 485/585 – Remote Sensing 1 – Fall 2021

Lab Assignment #1: Resolution and scale

Objectives: In this lab, you will learn the basic functions of QGIS and become familiarized with some of the multiple resolutions and scales encountered in remote sensing.

Logistics:

Date assigned:	Week 1
Date due:	Before the beginning of Week 2 labs
Points:	100 points
Deliverables:	Post a PDF document on Canvas with all answers and necessary graphics using the answer sheet given to you. Your responses are expected to be in complete, grammatically correct sentences based on knowledge gained from lecture, reading, and lab exercises. Remember that many of the questions have multiple parts so make sure you answer all parts of the questions.

Preface:

The lab instructions will be available on Canvas (canvas.uoregon.edu) and the class network drive (details below). Data used in labs are not posted on canvas and should be accessed through the SSIL network (you can also remotely connect to this network from off campus, following these instructions).

The class data is available at the following path:

`R:\GEOG485_12740_05\Class_Data\Lab1\`

You should store your work in a separate folder for each lab on your local computer. **Note:** I recommend anything you save on your local computer should also be backed up to a USB stick or Google Drive account at the end of each session. Your folder should have the following path (except has your own SSIL username):

`R:\GEOG485_12740_05\Student_Data\Your_Username`

For this lab, create a "`Lab1`" folder in which to store your work inside your user folder. Your lab write-up and any additional materials should be turned in online to the course website on canvas.uoregon.edu. Lab questions are due by the end of the lab, but it is suggested you do these questions first thing.

Lab overview:

In this first lab we will be working with an three different types of multispectral imagery that covers the Sisters Wilderness and surrounding area.

The goals of the lab are to:

1) Become familiar with operating in the lab and turning in work (e.g. where is the software, where data is stored, opening software, viewing data, saving work, and turning in lab work).
2) Use the QGIS software program to derive some basic information about the remote sensing datasets
3) Practice viewing remote sensing data and visualizing digital numbers as colors on the screen
4) Extract basic geographic, spectral, and thematic information from this data

1. Working with Landsat satellite data

In this lab we will be working with datasets available from `R:\GEOG485_12740_05\Class_Data\Lab1\data`. To start off, we will begin with the Landsat sensor. There should be seven Landsat files with each one corresponding to one band/channel. The number for each band is found at the end of each file name and is followed by a zero. For instance, the first file is *Band 1*, as indicated in the name: `Landsat8`**`_B1`**`.TIF`

2. Introduction to QGIS, image display, and color composites

For this lab, we will use the QGIS software package. This lab consists of displaying image data that is recorded in different wavelengths as both grayscale and color composite images. A wealth of information is contained within wavelengths that are outside of the visible part of the electromagnetic spectrum. The recorded wavelengths outside of the visible portion of the electromagnetic spectrum can be displayed as false color composite images.

QGIS is an image processing software that supports a wide variety of functions within an easy-to-navigate image-processing environment.

- Start QGIS from the Windows Start Menu (or Mac Launchpad).

2.1. Viewing and analyzing multiband satellite imagery in QGIS:

First we'll view the Landsat image using QGIS.

- From the top menu bar click **Layer** → **Add Layer** → **Add Raster Layer**. Click the three dots and navigate to the directory where the Landsat images are saved. Select all seven images, click **Open**, click **Add**. **NOTE:** You can also just drag the files into the QGIS workspace.

To make analysis of the Landsat imagery easier we will produce a composite that contains all of the bands. To do this:

- From the top menu bar navigate to **Raster → Miscellaneous → Build Virtual Raster**
- Click the three dots to the right of input layers and select all Landsat bands, click **OK**
- Resolution: Change the resolution to '*highest*'
- Make sure the box "*place each input file into a separate band*" is checked
- Click **Run**, then **Close**
- Right-click on the ***Virtual*** raster layer → **Rename Layer**. Change the name to '*Landsat8_Sisters*'

2.2. Natural color composite of the Sister Wilderness

We will now produce a natural (or true) color composite of *Landsat8_Sisters* with a color combination of Band 3 in the R(ed), Band 2 in the G(reen), and Band 1 in the B(lue).

- In the **Layer Styling** panel, set the second drop down menu to '*multiband color*'. This allows for the bands to be designated to the Red, Green and Blue color bands (*you can also right-click the layer, select **Properties** then **Symbology** from the left menu).*
- For a true color image, match the respective Landsat bands to the red, green, and blue band drop down boxes. Set **Band 4** to the **Red**, **Band 3** to the **Green**, and **Band 2** to the **Blue**. Click **Apply** and the true color image should be visible.
- This natural color composite image will look closer to what the human eye would see from space.

You can enhance the image to increase contrast between targets and their surrounding environment by "stretching" the grayscale display values based on the range of data in the bands.

- In the **Layer Styling** panel under **Contrast Enhancement**, change **Stretch to MinMax**
- Expand the **Min/Max Value** Settings. The default is set to **Min/Max**. Change it to **Mean +/- standard deviation** and set the value to '3*.00*'.
- For **Accuracy**, change it to **Actual (slower)**.
- Click **Apply**. If the 'Live Update' box is checked, the Min/Max statistics and the image will update on the fly, though it may take a few seconds to update. Note that for some settings you may need to press **Apply** for the Min/Max values to be displayed.
- Try different standard deviations, how does the image change? Also try the other options available for calculating the Min/Max statistics, and note the visual differences.
- Right-click on the '*Landsat8_Sisters*' layer → **Rename Layer**. Change the name to '*Landsat8_Sisters_true_color*'

***DISPLAY TIP: Making 'no data' values transparent**
The displayed image may have a black rectangle around the full extent of the image that we can change to be transparent.

- Using the **Identify Features** tool, click on the black background and you'll see '0' as the value for all bands.

- In the **Transparency** tab of the **Layer Stacking** panel, in **Additional no data value** add ‘0’ to classify the background pixels as ‘no data’.

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Question 1 (20 points): Identify five features/land covers/elements in this natural color image and briefly describe your thought process. *Remember scale, patterns, textures, color, prior knowledge etc.*

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2.3. False color composite of the Sisters Wilderness area

Now, produce a false color composite. A common color combination is 7, 6, 4, which assigns those sensor bands to the R(ed), G(reen), and B(lue) channels of the computer monitor, respectively.

- Right-click on the ‘*Landsat8_Sisters_true_color*’ virtual raster and select **Duplicate Layer**
- Rename the copy ‘*Landsat8_Sisters_false_color*’
- In the **Layer Styling** panel, select the ‘*Landsat8_Sisters_false_color*’ layer, and assign bands **7**, **6**, and **4** to the **Red**, **Green**, and **Blue** bands of the computer display.
- If necessary, adjust the display as before to make ‘no data’ values transparent and apply a contrast enhancement.

In order to view the two color composites simultaneously side-by-side, a new map view will be needed.

- Drag the false color raster in the **Layers** panel right below the other virtual raster, if it is not already. This allows us to keep the seven bands and virtual rasters separate in the layers list.
- To create a new map view, go to **View →New Map View**. This will create a new undocked window. You may keep the window undocked or dock it on the right side of the main window. Make sure to keep the layer styling panel open.
- In the **Settings** button in the new map view, select Rename View and type in ‘*False Color*’
- To view a different virtual raster in the ‘*False Color*’ map view, we need to create a new theme which will be shown in the new window. To start, make sure you have the ‘*Landsat8_Sisters_false_color*’ virtual raster selected in the layers panel so that it is highlighted in blue and the checkbox is ticked.

- Then go to the **Manage Map Themes** button in the **Layers** panel. Click **Add Theme**. Name this theme “*False Color*”.
- Then go to the **Manage Map Themes** button in the ‘*False Color*’ map view. Click the theme you just created. You should now see the new virtual raster in both windows. To view the original true color image, uncheck the ‘*Landsat8_Sisters_false_color*’ in the **Layers** panel. This will show the true color image in the main map view while keeping the new image in the new map view.

- In order to link the various map views together, in the **‘*False Color*’ map view** click on the **Settings** button, select **Synchronize view center with main map** and **Synchronize scale**. Note that the synchronized scale is maintained only if you scroll/zoom in the main map view. You may also adjust the **scale factor** as you see fit to either keep the new map view window at a higher or smaller zoom level compared to the main window. Clicking **Show main canvas extent** shows a box of the extent of the main windows view. Set the **scale factor** to *1* to synchronize scales.

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Question 2 (10 points): Which wavelengths (in nanometers) of light are now being displayed in each of the three RGB channels? You can use this link as a guide: https://www.usgs.gov/media/images/landsat-8-band-designations. Which land covers are now more distinct and what colors do they appear to be in the false color composite? Are any features less distinct?
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3. Analyzing individual pixels

3.1. Getting pixel coordinates

At the bottom of the QGIS screen, the **Coordinate** box tracks the pixel location in the units of the image Coordinate Reference System (**CRS**). The **CRS** is found by **Right-clicking** on the layer in the **Layer** panel and selecting **Properties**. The **CRS** of the Landsat image is *WGS 84 / UTM zone 10N - Projected*, and the units are in meters. To convert the coordinates into more recognizable **lon/lat** you need to enable the the **Coordinate Capture** tool.

- From the main menu bar, go to **Plugins → Manage and Install Plugins**
- In the **Plugins** window that opens, find the **Coordinate Capture** tool in the list of plugins, and check the box next to it to enable the tool.
- In the **Vector Toolbar** at the top click on the new **Coordinate Capture** tool

- In the **Coordinate Capture** panel, click on **Start Capture** and click on a location in the main map view. The first box shows the **longitude and latitude** of your cursor location (red dot in the main map view).

3.2. Getting pixel values

You can see individual pixel values for each image layer by using the **Identify Features** tool on the main **Attributes** Toolbar at the top. When this tool is selected and you click on a pixel in the main view window, the **Identify Results** panel pops up with values of all the bands in the image at that pixel.

- Have both your **natural color** image and **false color** image selected in the **Layers** panel.
- In the **Coordinate Capture** panel, click to **enable mouse tracking** and go to the snow covered area at **longitude** -121.79, **latitude** 44.68

Zoom into this area and note the differences in colors. The cyan color in the false color image represents snow. To understand why, let's look at a spectrum of all seven Landsat bands.

- Zoom further in and make sure you click on pixel within the cyan feature area.
- Use the **Identify Features** tool to click on that same pixel.
- The **Identify Results** panel pops up with values of all the bands in the image at that pixel for whichever layer you have on top.
- At the bottom of the **Identify Results** panel, for **View** select **Table**. This will list all the pixel values in any data layer selected in the **Layers** panel. Since both layers hold the same seven Landsat bands, the values will be the same for both virtual rasters (*Remember: while display colors can change with different band combinations, the underlying band values have not changed*).
- Another way to look at the pixel values is in graphical form. Again, at the bottom of the **Identify Results** panel, for **View** select **Graph.** The X-axis in this graph is for the number of bands and the Y-axis shows the pixel brightness value.

Let's compare the two composites by thinking in terms of the pixel brightness values. Compare the sparser cyan areas of the false color composite it to the uniformly bright, white areas in the true color composite. Also, you can look at the pixel brightness values of bright non-snow pixels. Your two map views (one with the *natural color* composite and the other with the *false color* composite) should still be synchronized.

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Question 3 (10 points): What do you see in the lower right of the true color Landsat image that does not show up very well in the false color image? Which bands are most useful for identifying this feature?
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Try different spectral band combinations (even trying the same band in different channels) to see how the features change color. You can do this by changing the band combinations in your '*Landsat8_Sisters*' virtual raster or creating a new virtual raster. Also try different contrast enhancements (change the ways the Min/Max is defined in the stretch).

4. Working with PlanetScope satellite data

In the next section we will be working with higher resolution imagery from the Planet Dove satellites. Load `PlanetScope_NRGB.TIF` image from `R:\GEOG485_12740_05\Class_Data\Lab1\data` into QGIS.

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Question 4 (10 points): Compare the spectral resolution (i.e. the number of bands and their spectral range) and temporal resolution of Landsat 8 and the PlanetScope sensors. **NOTE:** the PlanetScope image we have is from a DOVE-R satellite.
https://landsat.gsfc.nasa.gov/landsat-8
https://earth.esa.int/eogateway/missions/planetscope
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5. Viewing and analyzing high spatial resolution PlanetScope imagery

Open the PlanetScope image in QGIS. It should overlay on your current Landsat image.

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Question 5 (10 points): What is the pixel size of the PlanetScope image? To check, right-click on the PlanetScope image in the **Layers** panel, select **Properties** from the drop-down menu and **Information** from the panel on left. Scroll to the **pixel size**. The units are in meters as is stated in the **layer properties**. How does this compare to Landsat 8 image? Based on the dimensions of the two images, which would you expect to be a larger file size and why?
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We now have two images from different sensors which generally cover the same region – the PlanetScope image is smaller and is much more specifically covering the Sisters Wilderness.

- To locate the PlanetScope image, right-click on the image and select **Zoom to Layer**.
- Add a new map theme (as instructed for the false color composite) for a '*Landsat*' map view showing only the Landsat image.
- Turn off the Landsat image from the **Layers** panel so that the main map view now contains just the PlanetScope image.
- Use a **NIR-Red-Green** RGB composite for both images and apply contrast enhancement. This is called the *color infrared (CIR) composite*. **NOTE:** Since the PlanetScope image already contains all bands, there is no need to build a virtual raster. Instead, select the PlanetScope image and go to the layer styling window where you can assign the NIR-Red-Green (Bands 4,3,2) to RGB.

- Pan around the main map view PlanetScope image and note how differently the same landscape appears between the two sensors.

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Question 6 (20 points): Describe three features that are more distinguishable in the PlanetScope image than the Landsat image and provide their rough lat/on coordinates. The differences will be most visible by zooming into the PlanetScope image.
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6. Viewing and analyzing low spatial resolution MODIS imagery

In the last section we will be quickly looking at some low-resolution imagery from the MODIS sensor. Load the seven MODIS images from `R:\GEOG485_12740_05\Class_Data\Lab1\data` into QGIS.

- Produce a true color *virtual raster* and enhance the contrast. **HINT:** The RGB bands for MODIS correspond to Bands 1, 4 and 3, respectively.

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Question 7 (10 points): Compare and contrast the spectral and spatial resolution of MODIS with Landsat 8. Only evaluate the bands 1-7 of MODIS since they are all you have been given. You can view the specifications of MODIS in your book and at the following NASA web page: http://modis.gsfc.nasa.gov/about/specifications.php
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6.1. Comparing MODIS and Landsat

Add a new map theme for a 'MODIS' map view showing only the MODIS image, keeping the Landsat in the main map view. Use a **NIR-Red-Green** RGB false color composite for the MODIS and Landsat images. Synchronize the two maps.

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Question 8 (10 points): What features are recognizable with Landsat which are not with MODIS? List at least three types of features. As you can see, it's not so easy to detect many individual features with MODIS. Yet it is one of the most actively used satellite sensors in remote sensing today. Why would that be?
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This concludes Lab 1! Remember to type up all answers on the answer sheet, convert files to PDF and upload them to Canvas by the deadline.