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

Lab Assignment #2: Spectral transformations

Objectives: In this lab, we will explore the use of spectral transforms to investigate the health of vegetation and extent of snow across Oregon in July 2021.

Logistics:

Date assigned:	Week 2
Date due:	Before the beginning of Week 3 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\Lab2\`

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 "`Lab2`" 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:

The idea behind spectral transforms is to simultaneously compress and simplify the data into an easy-to-interpret measure. The objective is to produce 'new' images from the original data that increase the amount of information that can be visually interpreted from the data. NDVI stands for the *Normalized Difference Vegetation Index*. The first two words, normalized difference, indicate that it fixes the range of values to a set domain from –1 to 1, making it possible to compare the numbers between biomes. Its equation is as follows:

$$NDVI = \frac{NIR - R}{NIR + R}$$

Where NIR is the near-infrared band and R is the red band.

1.1. Import the data

First, add the five Landsat images from `R:\GEOG485_12740_05\Class_Data\Lab2\` to a QGIS workspace. This time I have not edited the names of the files. Before we start, let's look at what the file names of the Landsat images mean.

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Question 1 (10 points): Which wavelengths do these bands represent? When was this Landsat image acquired? What is the path/row of this image?
https://www.usgs.gov/media/images/landsat-8-band-designations
https://www.usgs.gov/faqs/what-naming-convention-landsat-collections-level-1-scenes?qt-news_science_products=0#qt-news_science_products
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1.2. Make a true color image

Produce a *virtual raster* from the RGB bands and display it as *true color* with contrast enhancement using the instructions (or memory) from Lab 1. Rename this layer '*true color'* by right-clicking the layer → **Rename Layer**.

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Question 2 (10 points): In Question 5 from Lab 1 we identified some clouds or smoke in the lower right of the true color Landsat image. Given what we now know about scattering of electromagnetic radiation, explain why the clouds/smoke is more apparent in the shorter wavelengths (blue/green bands) than the longer wavelengths (near-infrared/shortwave infrared bands).
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1.3. Produce an NDVI image

- Go to **Raster** → **Raster Calculator**.
- In the **Raster Calculator Expression** box at the bottom of the Raster Calculator window, enter the NDVI equation using the image bands appropriate for NIR (Band 5)

and Red (Band 4): **(NIR - Red) / (NIR + Red)**. Use the **Operators** to build the equation and choose the bands from the **Raster Bands** list by double clicking on the bands of interest. *Remember the brackets.*

- Choose a name and location for the output file (i.e. "`R:\GEOG485_12740_05\Student_Data\Your_Username\Lab2\NDVI.TIF`"). Select **GeoTIFF** as the output format. Then click **OK**.
- Compare the NDVI image to a true color image (RGB: Bands 4,3,2). You can compare them side by side using a new map view or see them layered over each other by turning the NDVI layer on and off over the true color image.

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Question 3 (10 points): What is the data range of the new NDVI layer? Explain why this makes sense given the equation. What do the high and low values represent? Switch between the true color and NDVI layers for guidance.

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It is useful to change the color scale of raster images to make them more intelligible. We will change the color scale so that green represents high values and white represents low values.

- Right-click the NDVI layer → **Properties** → **Symbology**.
- In **Render Type** change *Singleband gray* to *Singleband pseudocolor*
- Now change the **Color Ramp** to *Greens* and click **OK.**

1.4. Profiles

There is clearly a large difference in NDVI values east and west of the Cascades. There are several tools which can be used for gaining information about pixel values across space (a 'spatial profile') or information about a single pixel for multiple bands (a 'spectral profile'). To access the *Profile Tool* in QGIS:

- Go to **Plugins** from the top menu and **Manage and Install Plugins**
- Search for **Profile Tool**, click **Install Plugin** then **Close**
- Now go to **Plugins** again→ **Profile Tool** → **Terrain profile**
- Before you draw a profile, click **Add Layer** at the bottom right and add the NDVI layer
- Draw an east-west profile across the Cascades by left-clicking once to start and double left-clicking to finish. **NOTE:** both points have to be within the image boundaries or the profile will not show.
- Click **Save As** and save somewhere.

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Question 4 (10 points): Describe the general pattern of the spectral profile in terms of 1) absorption and reflection of electromagnetic radiation and 2) Oregon's physical geography. Include the PNG of the profile with your answer.

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There are some deviations from the general east-west trend. In other words there are some low NDVI values (0.1-0.2) west of the Cascades and some very high values (> 0.6) east of the Cascades.

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Question 5 (20 points): Identify two cases that deviate from the general east-west trend in NDVI, describe why you think they are anomalous, and provide their rough lat/lon coordinates.
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There are also some *negative* NDVI values.

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Question 6 (10 points): What surface type is generally responsible for these negative NDVI values? Identify an example of this surface type by providing rough lat/lon coordinates. Explain why these NDVI values are negative in terms of absorption and reflection of near-infrared and red electromagnetic radiation.
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2.1. NDSI

Now we will compute another spectral transform called the *Normalized Difference Snow Index (NDSI)*. This index is useful for identifying snow and the equation is as follows:

$$NDSI = \frac{G - SWIR}{G + SWIR}$$

Where G is the green band (Band 3) and SWIR is the shortwave infrared band (Band 6).

2.2. Produce an NDSI image

- Calculate an NDSI image using **Raster Calculator** like we did for NDVI.
- Choose a sensible name and location for the output file (i.e. "`R:\GEOG485_12740_05\Student_Data\Your_Username\Lab2\NDSI.TIF`").
- Now change the **Color Ramp** to *Blues.*

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Question 7 (20 points): What does the difference between the NDSI and NDVI layers tell us about the properties of snow vs. vegetation in terms of absorption and reflection of electromagnetic radiation?
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2.3. How much snow is there?

There appears to be plenty of snow on the mountains on July 18th 2021. It would be useful to know how much there is so that hikers can plan trips.

- Using the **Identify Features** tool, compare the *NDSI* and *true color* layers and determine a threshold value for discriminating snow from non-snow pixels. In other words, NDSI values higher than the threshold are likely to be snow but NDSI values lower than the threshold are likely to not be snow.

We will now perform a simple classification to determine how many pixels are classified as snow according to your chosen threshold.

- Go to **Raster→Raster Calculator**
- In the **Raster Calculator Expression** box enter the following equation:
  - `("NDSI@1" < x) * 1 + ("NDSI@1 >= x) * 2`
    where `x` is your chosen threshold
- *Choose a name and location for the output file (i.e. "`R:\GEOG485_12740_05\Student_Data\Your_Username\Lab2\Snow_Classification.TIF`"). Select **GeoTIFF** as the output format. Then click **OK**.*

The first part in the parentheses assigns a value of *1* to all pixels below your threshold (i.e. classifies them as non-snow). The second part in the parentheses assigns a value of *2* to all pixels above your threshold (i.e. classifies them as snow). Change the **Symbology** of the layer so that only the snow pixels are shown. You can do this by changing **Render Type** to '*Paletted/Unique values',* double-clicking the *Color* icon for **Value 1** and setting the **Opacity** to *0%.* Choose a nice color for the **Value 2** (i.e. the snow pixels). Display the *Snow Classification* layer on top of the *true color* layer.

Now we will find out how many of pixels were classified as snow. To calculate basic statistics for *`Snow_Classification.tif`* go:

- **Processing** (from the top menu)→**Toolbox**→**Raster analysis**→**Raster Layer Zonal Statistics** OR type "zonal statistics" into the bottom left search bar.
- In the **Raster Layer Zonal statistics** window, choose your *Snow Classification* raster layer as both the **Input Layer** and **Zones Layer**, click **Run** and **Close**.
- Right-click on the new layer which should be called '*Statistics'* and select **Open Attributes Table**.

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Question 8 (20 points): What NDSI threshold did you choose? How many pixels were classified as snow? What is the total coverage of snow in km^2? What is the total coverage of snow as percentage of this Landsat image (excluding NoData values)? Include a PNG of a specific area that demonstrates your classification with your answer.
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This concludes Lab 2! Remember to type up all answers on the answer sheet, convert files to PDF and upload them to Canvas by the deadline.