**Geology 340 – Images of the Earth**

**Lab 9 – Fun with Rasters!**

**Data Download**

Download the Lab 9 data from the course web page and unzip it to a working directory on your computer. You'll also need the Lab 8 data for the last problem, so make sure you've got that downloaded onto your computer.

**Aral Sea**

Today we will be looking at satellite photos of the Aral Sea in Kazakhstan. The Aral sea has lost much of its water due to use by nearby farms and industry. This has hurt the local economy and fishing industry severely and exposed contaminated lake sediments to the air. In this activity, you will explore the extent of the drying using satellite photos.

1. In the Lab 9 Data package there is a folder called Aral Sea. Create a new ArcMap document and add the two JPEG images from 1987 and 1997 to the map. They have no coordinate system, but that's OK – they already should line up with each other.
2. ***You may also need to turn on the Spatial Analyst extension (under Customize -> Extensions).***
3. We want to select the water part of the images and compare their size. You'll note that the 1987 image does not cover the whole image area, though, and there is a black zone at the right side that might be confused with water. Therefore, we need to set the region we're interested in to avoid that area of the image. Move your mouse over the 1987 image and look at the bottom of your ArcMap screen – you should see the pixel coordinates of your mouse cursor changing. Figure out how far to the right you can go using this coordinate system without including bad pixels.
4. Open the Toolbox, go to Spatial Analyst Tools, The Reclass item, and pick the Reclassify tool. Choose the 1987 image as the input raster.
5. To set your extents, pick “Environments” from on the Reclassify panel. Go to “Processing Extent.” Choose “Same as Aral1987.jpg” initially – it should show numbers representing the whole region. Modify the value in the box marked Right to exclude the right side of the image. You may also want to shift the Left value to eliminate the scale box, which also has black pixels. Click OK to exit the Environments pane.
6. Now we can select the lake area. Click the “Classify” button. You should see a histogram graph of pixel values. You can see many values near zero – these are the lake values. Set the number of classes to two, and you should see two classes. Go ahead and run the classification.

You should get a new layer with a classification into two values. If you didn't alter the boundaries, you should note that you get all of the lake area classified, which is good, but you also get a bunch of stray pixels elsewhere. Not so good. **Screen capture your first try and submit it with what you turn in. (2 points)**

1. Try to fix this problem by picking a different boundary between your two classes in the reclassification. If you’re picking too many non-lake pixels, put your boundary closer to black, and if you’re missing out on picking lake pixels that should be lake, put your boundary higher up. You can do this by entering values in the reclassification table or by dragging around the boundary on the histogram. How good a classification can you get? **Screen capture this revised try and submit it with what you turn in. (2 points)**
2. Another way to fix this problem is to filter the data to eliminate the isolated points. Go back to the Aral1987 layer and do the default two-class classification. Now, select this classification and pick “Neighborhood” and then “Block Statistics” off of the Spatial Analyst Tools section of the Toolbox list. The default settings are for a 3x3 neighborhood – this means that each cell in the new layer will be based on the values of itself plus the eight cells surrounding it – so, you're getting a regional averaging effect. Change the Statistic Type to Majority – this means that each cell will be set to the value of the majority of those nine cells. This should eliminate any single-pixel false water values, because they'll be surrounded by non-water pixels. Go ahead and run the classification.

Your new layer should be called something like “BlockSt\_Recl1” unless you’ve been renaming the layers. You should see a nice two-class classification showing water and land with most of the stray false water values removed. **Screen capture this version and turn it in with your lab (6 points).**

1. Using this new layer, click on “Zonal Statistics as Table” from the “Zonal” section of the Spatial Analyst Tools part of the Toolbox. Run a statistical analysis of your classified layer. You can use the classified layer for both input rasters. **(6 points)**
	* How many water pixels do you have?
	* How many land pixels?
2. Repeat the water/land classification scheme described above for the Aral1997 layer. **Export this image, submit it, and report your statistics below:** **(12 points)**
* How many water pixels do you have?
* How many land pixels?
1. Based on these two images, what percent of the Aral Sea's area was lost during the ten years that elapsed between these two times? **(4 points)**
2. Can you say anything about the volume of the Aral Sea from this calculation? What other information would be helpful for this calculation? How might you use it with the Spatial Analyst functions? **(6 points)**

***OPTIONAL***: If you're adventuresome, there's an image from 1962 which covers part of the Aral Sea. You can georeference it to one of the others, change the extents and compare the water coverage for the section of the sea it shows. If you do this, submit the classified images and report the size change relative to the other images. **(up to 5 bonus points possible)**

**Multi-band images**

When using aerial photos or satellite images, you often have access to multiple spectral bands of data. Sometimes, you can do mathematical operations on these bands in order to learn something interesting about the area that the single bands wouldn't tell you. Here are the bands measured by the Landsat Thematic Mapper satellites:

| **Band**  | **Spectral Range** **(in Microns)** | **EM Region** | **Generalized Application Details**  |
| --- | --- | --- | --- |
| 1 | 0.45 – 0.52 | Visible Blue | Coastal water mapping, differentiation of vegetation from soils  |
| 2 | 0.52 – 0.60 | Visible Green | Assessment of vegetation vigor  |
| 3 | 0.63 – 0.69 | Visible Red | Chlorophyll absorbtion for vegetation differentiation  |
| 4 | 0.76 – 0.90 | Near Infrared | Biomass surveys and delineation of water bodies  |
| 5 | 1.55 – 1.75 | Middle Infrared | Vegetation and soil moisture measurements; differentiation between snow and cloud  |
| 6 | 10.40- 12.50 | Thermal Infrared | Thermal mapping, soil moisture studies and plant heat stress measurement  |
| 7 | 2.08 – 2.35 | Middle Infrared | Hydrothermal mapping  |
| 8 | 0.52 - 0.90 (panchromatic) | Green, Visible Red, Near Infrared | (only on more recent Landsat images) |

Table from Geoscience Australia.

**NDVI**

One of the most common of these mathematical operations is the Normalized Difference Vegetation Index (NDVI). This is a ratio involving the red and near-infrared parts of the spectrum, frequently recorded by satellites such as Landsat and AVHRR. The ratio is calculated as follows:



 The numerator means that areas with higher infrared than red reflectance will have a higher NDVI. The denominator ensures that variations in the overall brightness of the image in these bands will not unduly influence the NDVI result. The NDVI ranges from +1 to -1, with positive numbers indicating healthy vegetation. Typically, healthy plants will reflect strongly in the infrared part of the spectrum and absorb strongly in the red part of the spectrum. This has to do with the biomass and leaf structure of the plant and the fact that chlorophyll uses red light to photosynthesize (so more chlorophyll means less red light reflected). Rocks and dirt have the same reflectance in these two bands, so they come out to an NDVI of zero, and water has almost no infrared reflectance, so the NDVI is negative.

1. Load all seven bands of TM data from the Wagga Wagga directory. This is imagery of a town in Australia.
2. Examine the bands and compare them to the table above. Note which bands are reflective in which parts of the image. Band 6 is collected at a much lower spatial resolution than the other bands, and you can see that in the image.
3. Load the WaggaRGB.tif image and see how it looks. It should look more like a regular picture, but it's not exactly – it uses channel 1 as blue, channel 2 as green, and channel 3 as red, but those channels and their relative intensities don't necessarily line up with what you'd see with your eye or with what the computer chooses to display. **What do you think would be different with a true RGB photographic image? (2 points)**
4. Use the Raster Calculator feature of Spatial Analyst to set up the appropriate calculation for the NDVI with the appropriate channels.

NOTE: The raster calculator has trouble creating numbers with decimal places as its result, so you may want to multiply your NDVI calculation by some large number (e.g. 1000) to ensure you preserve the variability in your data, or you can use the *float* function to make it a floating point number. Otherwise, you may just end up with values of -1, 0, or 1, with nothing in between.

**Export your Raster Calculator image from #4 above as a JPEG and submit it with the lab. (10 points)**

**Desperate Poets**

Integrative studies major Biff LeBeau wants to find a place to write poetry for his experiential thesis work. Use the Guilford campus data from Lab 8 to find a good spot from him. His requirements are:

1. He'd like to be near the cafeteria
2. He'd like to be near the lake, and have a view of it if possible
3. He'd like to be far from traffic noise
4. He'd like a flat area to set up his sweatlodge

Each of these parameters is equally important to Biff. Use spatial analyst to find a good location for Biff's private reflection using a method similar to what we did for the Vermont schools in class.

NOTE: When you do your distances, slopes, and calculations, it would be good to use the Guilford Property Line layer as the extent of your analysis.

**Describe briefly how you incorporated each of Biff’s four requirements, and submit an image showing the best sites for Biff’s work. (30 points)**