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

Lab Assignment #5: Change detection

Objectives: We will use the Landsat record to quantify lake changes of the Salton Sea over a 47-year period.

Logistics:

Date assigned:	Week 5
Date due:	Before the beginning of Week 6 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 some 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\Lab5\`

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 "`Lab5`" 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 start of the next lab, but it is suggested you do these questions first thing.

Lab overview

The Salton Sea is a shallow, landlocked, highly-saline body of water in southern end of California created by an accidental inflow of water from the Colorado River in 1905. It formed because the head-gate of an irrigation canal, designed to provide water to the Imperial Valley for farming, burst in 1900 due to spring floods, diverting a portion of the Colorado River into the Salton Basin for two years before repairs were completed. The modern lake is now around 889 km^2. The only inflow to the lake is from the surrounding farms in the Imperial Valley which often contain high levels of contamination and salinity.

Since 1990s, the lake began to shrink as local agriculture made more efficient use of water. As the lake bed became exposed, the winds sent clouds of toxic dust into nearby communities. Smaller amounts of dust reached into the Los Angeles area and people there could sometimes smell an odor coming from the lake. At the beginning of 2018 local agencies declared an emergency and along with the state funded and developed the Salton Sea Management Program. After a slow start and some small projects, construction started on a $206.5 million project in early 2021 on the delta of the New River, creating ponds and wetlands on the southern and southeastern shore of the lake.

In this lab we will use the Landsat record to quantify lake changes of the Salton Sea over a 47-year period.

1. Import data

- Import all the Landsat images from `R:\GEOG485_12740_05\Class_Data\Lab5\data\` into your QGIS workspace. There should be eight layers which represent four images (two bands for each).

2. Resample data

To perform lake change detection, we need all our images to have a common spatial resolution and extent. In this case, our Landsat 1 image has coarser spatial resolution than the others (60 m vs. 30 m). In addition, the Landsat 1 and Landsat 5 images have a much larger extent than the Landsat 8 image. We will need to resample and clip our images. To do this, first identify the two Landsat 1 layers which have 60 m spatial resolution and resample both layers to the same resolution as the other layers.

- Check the information of each layer by double-clicking on the layer in the **Layers** panel and scroll down to see the **Pixel Size**. Make note of the pixel size (units are in meters). While you are here, also check the **CRS (Coordinate Reference System)** and make note of it.
- Now go to **Raster → Projections → Warp (Reproject)**. Even though we're not changing the projection, this tool will allow us to both resample the pixel size and change the output extent.
- In the **Input layer** field select one of the Landsat 1 layers.
- For the **Resampling** method to use, select "*Nearest Neighbour*"

- For the **Output file resolution in target georeferenced units**, type in the spatial resolution of pixel size (30 meters).
- Under **Advanced parameters**, in the **Georeferenced extents of output file to be created**, click on the three dots to select **Calculate from Layer** and choose either of the Landsat 8 layers.
- At the bottom of the **Warp (Reproject)** window, in the **Reprojected** field click the three dots to choose **Save to File**. Navigate to your `R:\GEOG485_12740_05\Class_Data\Lab5` folder, make a new folder called “`data_resampled`” and save it as “`LAYER_XXm_Clip.TIF`”, where “`LAYER`” is the layer name of the original image and “`XX`” is the new spatial resolution in meters, and click **Run**.
- Now repeat the above steps to resample and the other Landsat 1 layer.

Now clip the four Landsat 5 layers so they have the same extent as the Landsat 8 layers. You can do this using the steps above except leave **Output file resolution in target georeferenced units** as “*Not set*”.

After this step, your images should have a common spatial resolution and extent and can now be directly compared.

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Question 1 (30 points): Provide some details for each of the eight layers by making a table showing:

a) Sensor (e.g. Landsat 8)
b) Date of image acquisition
c) Band (e.g. Band 4)
d) Wavelength range
e) Original spatial resolution (in meters)
f) Original extent (i.e. number of rows and columns)
g) New spatial resolution
h) New extent

Use the following as a guide: https://www.usgs.gov/faqs/what-are-band-designations-landsat-satellites?qt-news_science_products=0#qt-news_science_products
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3. Prepare data

Produce a Normalized Difference Water Index (NDWI) for each image using **Raster Calculator** (use instructions from Lab 2 Section 1.3 if you need a reminder) and the equation below:

$$NDWI = \frac{G - NIR}{G + NIR}$$

where G is Green (Band 4 in Landsat 1, Band 2 in Landsat 5, and Band 3 in Landsat 8) and NIR is near-infrared (Band 6 in Landsat 1, Band 4 in Landsat 5, and Band 5 in Landsat 8).

- Save these new layers in your student folder as “`LX_NDWI_ZZZZ.TIF`” where “`X`” is the Landsat satellite and “`ZZZZ`” is the year the image was acquired.

4. Define a threshold for water

Now you want to extract the water pixels from the surrounding land in the ratio images. In order to do this you will investigate the histogram.

- Starting with the “`L8_NDWI_2020`” layer, in the **Layer Styling** panel go to the **Histogram** tab and click on **Compute Histogram**.
- In the histogram, you will see two peaks. The one on the left (with lower ratio values) represents the water pixels and the right one (with higher ratio values) represents the land pixels.
- Since you are interested in just the water values, find a threshold in this ratio image separating water from land. Click on the hand sign which allows us to **pick a max value on the graph** button and select a value about half way between the land values and water values
- Note what your Max value is
- Repeat these steps for the other NDWI layers and take note of the threshold values

5. Mapping the Lakes (classification)

We need to produce a simple classified image where a value of 1 represents water and a value of 0 represents not-water (i.e., land).

- Go to **Raster→Raster Calculator**. Add the following expression in the **Raster Calculator Expression** box:

```
LX_NDWI_ZZZZ > threshold value
```

- where, where “`X`” is the Landsat satellite and “`ZZZZ`” is the year the image was acquired and “`threshold value`” is the value you identified in *Step 4*.
- Choose a file name for the **Output layer** (i.e., “`L8_NDWI_2020_classified.tif`”) and click **OK**. This should appear in your **Layers** panel
- Repeat these steps for the all four NDWI layers and their respective threshold values.

6. Post-classification corrections

You may see in your classified images that your lake areas or land areas contain isolated pixels, or ‘speckle’. In order to remove this, you need to perform a post-classification correction, similar to what we did in Lab #4.

- Go to **Raster→Analysis→Sieve**
- Select one of your classified layers as your **Input layer**.
- The **Threshold** tells the algorithm to remove raster polygons smaller than this size. Start with a value of “*10*”.
- Click **Run**

- This should produce a new temporary layer called "*Sieved*". If there are still speckles in the image, remove this layer and repeat the first four steps with a different threshold
- Note: if the new "*Sieved*" looks weird, double-click the layer, then **Symbology** from the left-hand-side menu. Make sure the **Min** is set to *0* and the **Max** is *1*.
- When you are satisfied with your final water classification, right-click the "*Sieved*" layer and **Export → Save As** and save in your Lab #5 folder and save as "`LX_NDWI_ZZZZ_postproc.tif`"
- Repeat these steps for all four classified images

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Question 2 (10 points):

a) Which threshold did you use for each image?
b) Which sieve threshold worked best for removing salt-and-pepper effects?

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7. Change detection

7.1. Change maps and statistics

We can now calculate change statistics from our four classifications. First, let's make a change map for 1973 to 1995 by differencing the two respective layers.

- Go to **Raster→Raster Calculator**. Using our 1973 and 1995 post-classification layers, input the following expression in the **Raster Calculator Expression** box:
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```
L5_NDWI_1995_postproc – L1_NDWI_1973_postproc
```

- This expression subtracts the 1973 image from the 1995 image:
    - A value of "0" indicates no change
    - A value of "1" indicates pixels that were land in 1973 became water in 1995
    - A value of "-1" indicates pixels that were water in 1973 became land in 1995

- Choose a file name for the **Output layer** (e.g. "*`Change_1973_1995.tif`*") and click **OK**. A new layer should appear in your **Layers** panel.
- Repeat these steps to produce a change map between all four layers (i.e. 1973→1995, 1995→2011, 2011→2020)

With these three change maps, you can generate a statistics report to find the number of pixels representing areal extent changes between each pair of images.

- Go to **Processing→Toolbox**, and in the search field type in the **Raster layer unique values report** and open the tool.
- Select "*`Change_1973_1995.tif`*" as the **Input layer**, and under **Unique values report** click the three dots to **Save to File** and choose a file name (i.e., "`Change_1973_1995.html`").

- The result will be an *.html* file listing the number of pixels and the area (square meters) for each change class.
- Repeat these steps to generate the statistics report for the other change maps.
- You can open these *.html* files in a web browser.
- Note that any value that is not -1, 0 or 1 is likely to be a NoData value, you can ignore these values.

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Question 3 (20 points): Copy and paste your three change map images. Describe the changes that have occurred during this time period.
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Question 4 (20 points): Produce a table showing the lake area change in km^2 for all three periods.

a) In which period did the Salton Sea experience the greatest loss of area?
b) What was this loss as a percentage of the total area of the Salton Sea?

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7.2. Multi-date change detection map (Write Function Memory Insertion)

To visualize land cover change between all dates at one time, you can use the Write Function Memory Insertion technique. This simply creates an RGB color composite image to qualitatively inspect change in multi-date imagery.

- First we will merge three of the post-classified images into one multiband raster (1995, 2011 and 2020)
- Go to **Raster→Miscellaneous→Merge**.
- In the **Input layers**, click the three dots and select the 1995, 2011 and 2020 post-classification images. Make sure to drag the layers in order of time from earliest to more recent (see below). It is important to note the order of the three files now because they will become labeled as “Band 1”, “Band 2”, and “Band 3” in the merged raster. The click **OK**

- Check the box next to **Place each input file into a separate band**.
- Under **Output data type** choose “*Byte*”.
- In the **Merged** field click on the three dots to **Save to File** and choose a filename to save. Then click **Run**. The new file will appear in your **Layers** panel.
- Go to the **Layer Styling** panel and select your new merged raster. Load a multiband color image with the following setting: R = 1995, G = 2011, and B = 2020.

At first this composite image will display as completely black. Apply a contrast enhancement (e.g. **Min/Max stretch**) to the image in order to view the final RGB change detection composite image appropriately. Use the **Identify features** tool to find the pixel values to help interpret the colors in the image, with a value of '*1*' indicating a water class pixel.

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Question 5 (20 points): Copy and paste your multi-date RGB composite image below. Describe the meaning of each color in the image.

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This concludes Lab 5! Remember to type up all answers on your word document, convert files to PDF and upload it to Canvas by the deadline.