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EXERCISE 5
Change thresholding

Introduction

Detecting land cover changes using remotely sensed imagery is a multi-step process, requiring careful image processing, change algorithm selection, and threshold placement to delineate areas of change from non-change. While there are multiple accepted methods for establishing change thresholds, they generally fit into three groups: automated, manual, or semi-automated techniques. This exercise will provide an overview of basic manual change thresholding methods, which will serve as a foundation for more advanced change detection methods.

Objectives

- Review the standardized difference image
- Manually place change thresholds
- Create change map

Required Data

- **Standardized difference image: zdiff_2002_2011_NorthernAZ_NDVI.tif –** This image is the output from exercise 4. It is the standardized difference between NDVI in time 1 (2002) minus the difference in time 2 (2011). Negative values (represented by darker tones, or the color you applied with your custom symbology) indicate an increase in NDVI while positive values (represented by lighter tones, or the color applied with your custom symbology) indicate a decrease in NDVI. The raw difference between 2002 and 2011 was converted to z-scores in order to standardize the values and ensure that results are interpretable across space and time.

Prerequisites

- You have **ArcGIS 10.x** installed on your machine with the **Spatial Analyst** extension enabled.

Note: It is assumed that you will use the provided course data; you can, however, run through this exercise using a difference layer from any coregistered image pair. While the difference image we use employs NDVI, you can use the difference between time 1 and time 2 from any single band (e.g., blue band, NIR band, etc) or any image enhancement (e.g., SAVI, Tasseled Cap features, SR, etc). Calculating z-scores is not essential, though it is advised.

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Part 1: Review the standardized difference image

A. Open the NDVI difference image

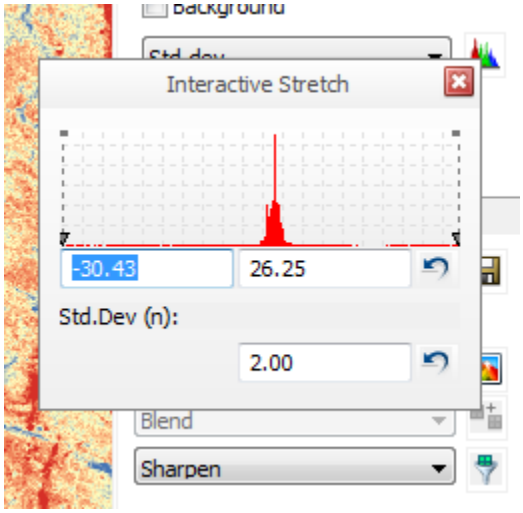
1. If you've closed ArcGIS between exercises, open the NDVI images.
   i. Click the **Add Data** button
   ii. Navigate to your working folder and select the standardized difference image, **zdiff_2002_2011_NorthernAZ_NDVI.tif**
   iii. Click **Add** to load the image.

B. Investigate the histogram

1. Open the **Image Analysis** window by going to **Windows** and then selecting **Image Analysis**.
2. Make sure that the standardized difference layer is checked and selected.
3. In the Display panel, select the Interactive Stretch Tool button (shown below).

4. If the button is grayed out (shown below), you will need to calculate histograms.

   i. Select the drop down showing **Std-dev** as the selected option and select **Percent Clip**
   ii. When asked if you would like to compute histogram, select **Yes**.
5. An interactive Stretch window will appear, allowing you do view the distribution of pixel values for the entire image. Remember that since we are looking at a z-score image, the values tell us how many standard deviations the pixel falls from the mean.



6. By dragging the vertical bars or adjusting the min/max values, we can adjust the symbology of the image, assigning a certain portion of the image with a single color.

Part 2: Manually place change thresholds

A. Threshold image in to areas of change and non-change

In a histogram of a difference image, the majority of the pixels will represent areas of non-change (i.e., they will fall close to the median), whereas areas that have experienced change will fall somewhere in the tails. The goal of thresholding is to find the "sweet spot" in the histogram that delineates the change portions (tails) from the non-change portion. There will likely be two such values, one for each side of the histogram.

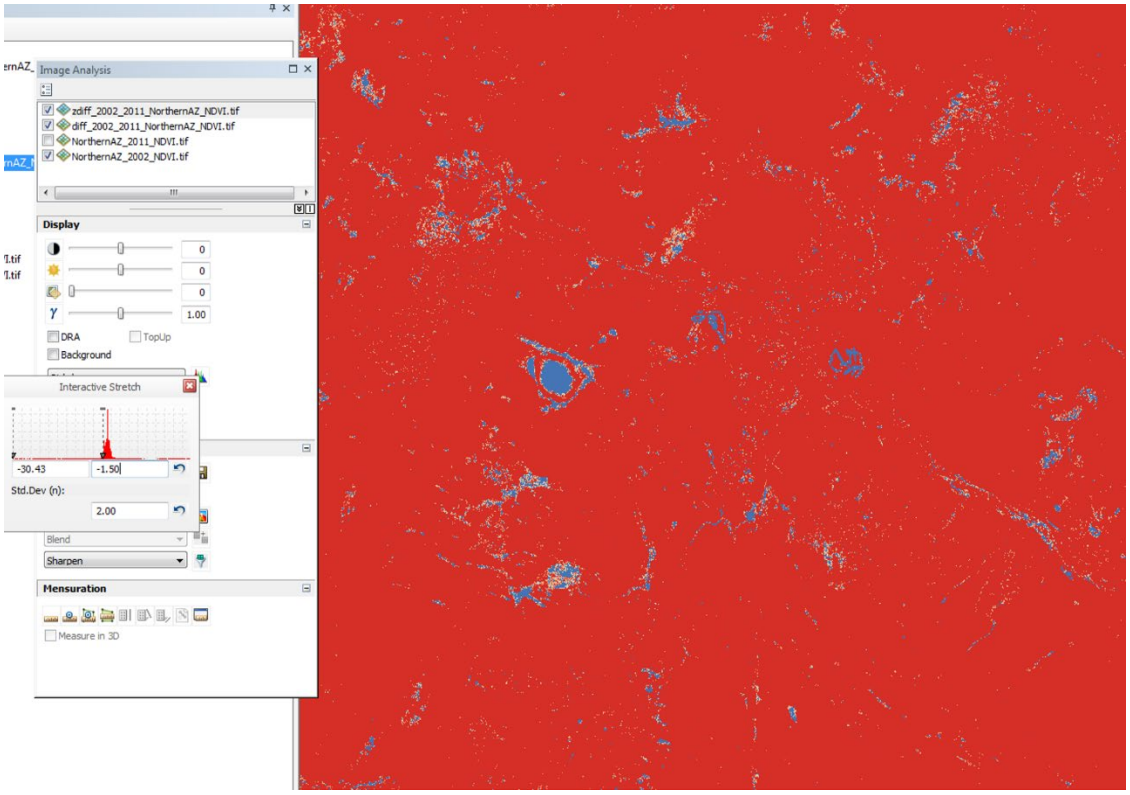
1. If the Interactive Stretch window isn't open, click the button to open it.
2. Beginning with the left tail (representing areas that have increased in greenness), start experimenting with threshold placement.
   i. Change the **right display threshold** to -10 and press enter. What happens to your display?

Note: Any pixel in your image with a value greater than -10 will be assigned the same color, allowing you to clearing see all of the pixels that fall within the left tail. You should be able to see some crisp and very obvious increases in greenness, like a gold course.

   ii. Change the **right display threshold** to 0 and press enter. What happens to your display?

Note: There are so many pixels with values ranging from the minimum to 0. With this threshold, we can see a lot of non-change pixels being included in the left tail. This threshold is too liberal, and it needs to be set lower/further to the left.

   iii. Keep experimenting until you find a threshold that seems to encapsulate changes well without committing too many pixels as change. When you're done, your viewer should look similar to the graphic below.



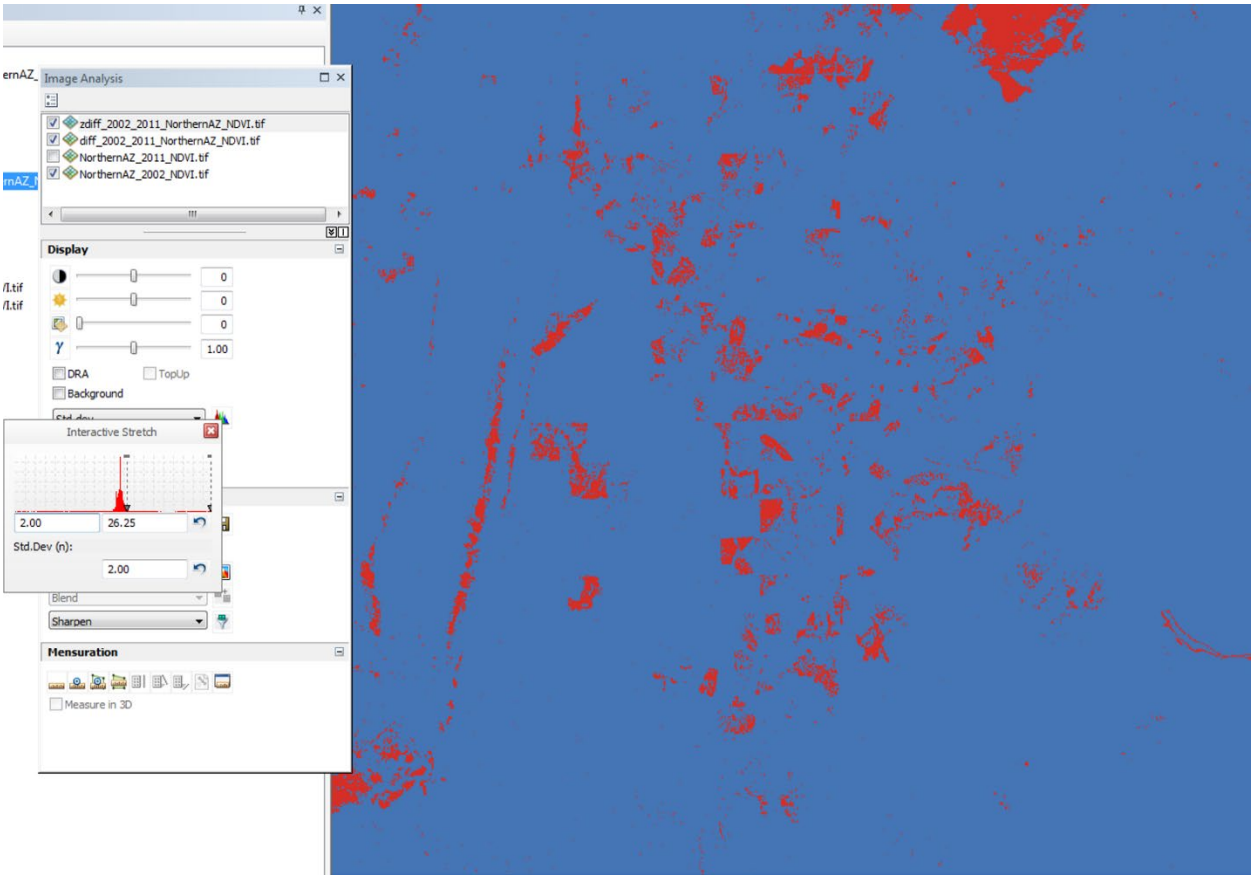
3. In a text editor or on a sheet of paper, make note of the threshold that you chose.
4. Click the reset button (to the right of the threshold fields) to revert to the original display.
5. Move on to the right tail (representing areas that have decreased in greenness), and start experimenting with threshold placement.
   i. Change the **left display threshold** to 10 and press enter. What happens to your display?

Note: All but a handful of pixels in your image have values less than 10, so it should appear as though your entire image is one color. This threshold is far too exclusive; it needs to include a wider range of values to encapsulate any meaningful change.

   ii. Change the **left display threshold** to 0 and press enter. What happens to your display?

Note: This looks much better, but we now have the opposite problem – the threshold is a little bit too inclusive, and it's calling too many pixels change.

   iii. Keep experimenting until you find a threshold that seems to encapsulate changes well without committing too many pixels as change. When you're done, your viewer should look similar to the graphic below.



6. In a text editor or on a sheet of paper, make note of the threshold that you chose.
7. Click the **reset** button (to the right of the threshold fields) to revert to the original display.

Part 3: Create a change map

A. Use thresholds to create a thematic change map

1. Open the **Reclassify** tool.
   i. Select **Geoprocessing** and then **ArcToolbox**
   ii. Expand the **Spatial Analyst Tools**
   iii. Expand the **Reclass** tools
   iv. Double-click on **Reclassify**
2. Select your standardized difference layer as the **input raster**
3. Adjust your **Old Values** based on your thresholds
   i. The first record should range from the minimum to the lower threshold
   ii. The second record should range from the lower threshold to the upper threshold
   iii. The third record should range from the upper threshold to the maximum
4. Specify the output filename

i. Click the **yellow folder icon**
ii. Navigate to your working directory
iii. Name your output **NorthernAZ_change_2002_2011.tif**
iv. Click **Save**

5. Click **OK** to run.
6. Use the **swipe** tool to examine the quality of your change map.

Congratulations! You have completed the final exercise for this introductory change detection training. You have created a simple change map representing areas that have increased or decreased significantly in NDVI. This thematic change map has 3 classes corresponding to increases in NDVI, no change, and decreases in NDVI. This is a very simple change map that demonstrates basic concepts related to classifying change. This map should be validated using reference imagery before it is put to use.