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Geography 371
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December 13th, 2019

Lab 12

Introduction

This lab assignment presented the challenge of accurately and effectively capturing land cover changes using two dates of satellite imagery while testing two different change detection methods. In particular, agricultural expansion and intensification in Xinjiang, China dating from 2002-2017 were examined using the Image Differencing Method, and a K-Means Unsupervised Classification.

For as long as civilizations have existed, humans have cultivated the Earth to acquire natural resources such as food, materials, and energy. While farmlands today dominate 38% of the Earth's land surface (Zabel et al.), the current pace of farmland production will not be able to support global populations as demand for agricultural commodities will inevitably rise due to population levels exponentially increasing.

While scientists seek alternative methods to deal with this growing issue, there is pressure on farmers to grow crops in the most efficient means possible. As a result, analyzing agricultural expansion and intensification proves useful to help seek these methods.

Methods

There are two approaches when performing unsupervised multi-date change detection.

The first approach produces a categorical output using clustering algorithms, such as *the K-Means method.* The second approach produces a continuous output, and one way of doing this is through *image differencing.*

The K Means method is a classifier algorithm that is able to discern patterns of *change* and *no change* in the spectral value of the two images.

In this case, the analyst begins by creating a multi-date image stack by generating a file that has all bands of both dates of imagery. Following this, the analyst runs the K-Means classifier, where *Number of Classes, Change Threshold,* and *Iterations* are manually inputted.

For this lab, the Number of Classes, Change Threshold, and Iterations were as followed:

Parameters:	**Input:**
Number of Classes	75
Change Threshold	5
Iterations	20

Figure 1.

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Following this, the resulting clusters are analyzed, then manually grouped into classes.

For the K-Mean's method, the final classes were as followed:

Class:
High Vegetation Loss (Dark Red)
Medium Vegetation Loss (Med Red)
Slight Vegetation Loss (Light Red)
No Change (Gray)
Slight Vegetation Gain (Light Green)
Medium Vegetation Gain (Med Green)
High Vegetation Gain (Dark Green)

Figure 2.

From this classification method, the K-Means Map is produced.

Image Differencing is a very simple method for change detection. In this case, the analyst subtracts the 2017 image's NDVI band from the 2002 image's NDVI band. If there is no change, then the values produced from the image differencing would be 0.

However, in this case between the 2017 image and 2002 there are differences in the vegetation indexes. Once the resulting differencing image is produced, the analyst manually performs a density slice, editing the raster color slices of the pixel values with the *no change* areas appearing in the center of the histogram distribution and the *changed areas* appearing on the positive and negative sides of the *no change* areas.

For this lab, the histogram was divided into 7 separate classes:

Class:	**Minimum Value:**	**Maximum Value:**
High Vegetation Loss (Dark Red)	-4.427985	-.60000
Medium Vegetation Loss (Med Red)	-.5999999	-.30000
Slight Vegetation Loss (Light Red)	-.2999999	-.11000
No Change (Gray)	-.1099999	.109999
Slight Vegetation Gain (Light Green)	.11000000	.299999
Medium Vegetation Gain (Med Green)	.30000000	.599999
High Vegetation Gain (Dark Green)	.60000000	1.259765

Figure 3.

From this classification method, the Image Differencing Map was produced.

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Results

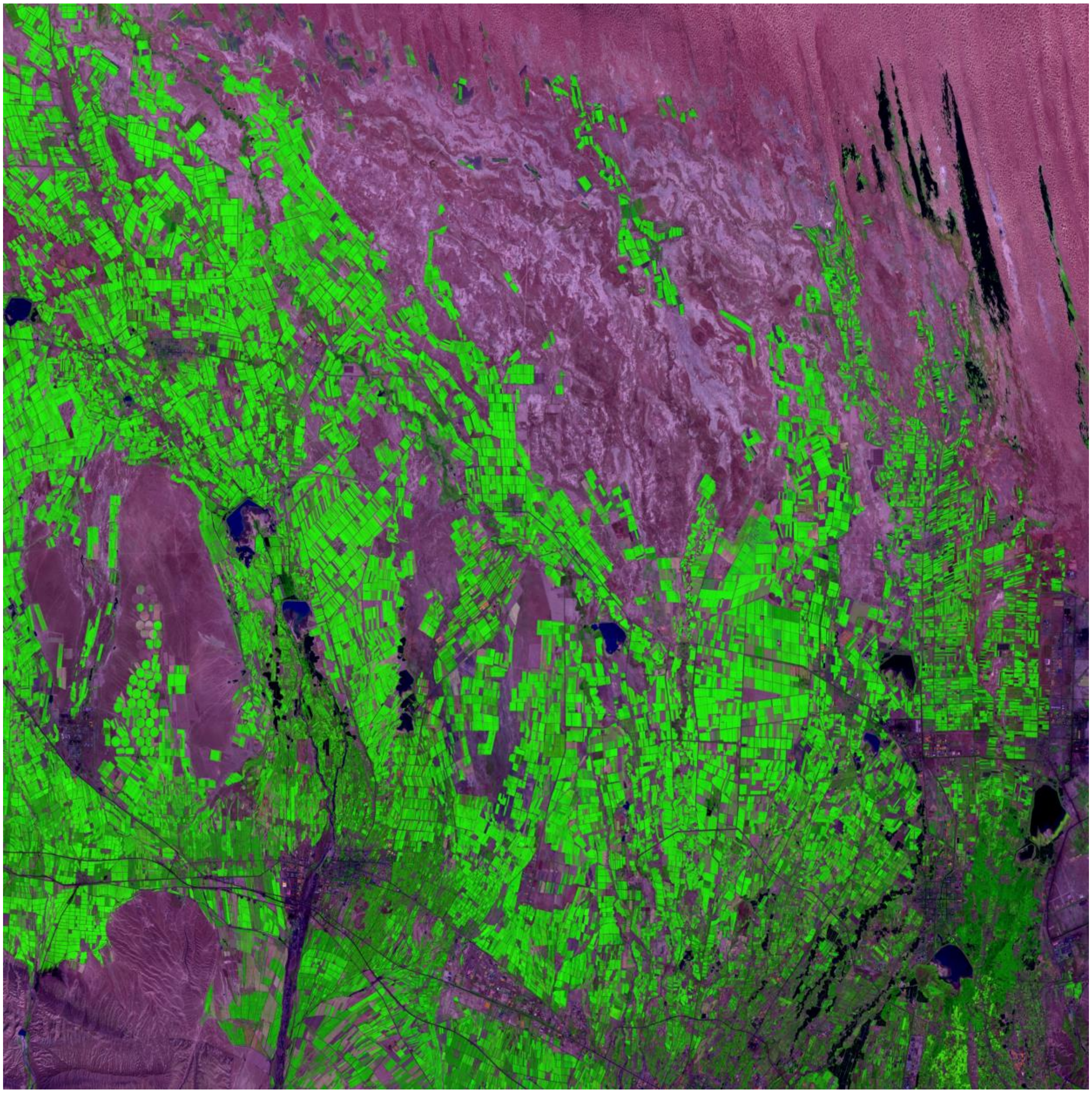

Figure 4. Landsat image of Xinjiang, China. 2017. Band Combination: 5 Red, 4 Yellow, 3 Blue.

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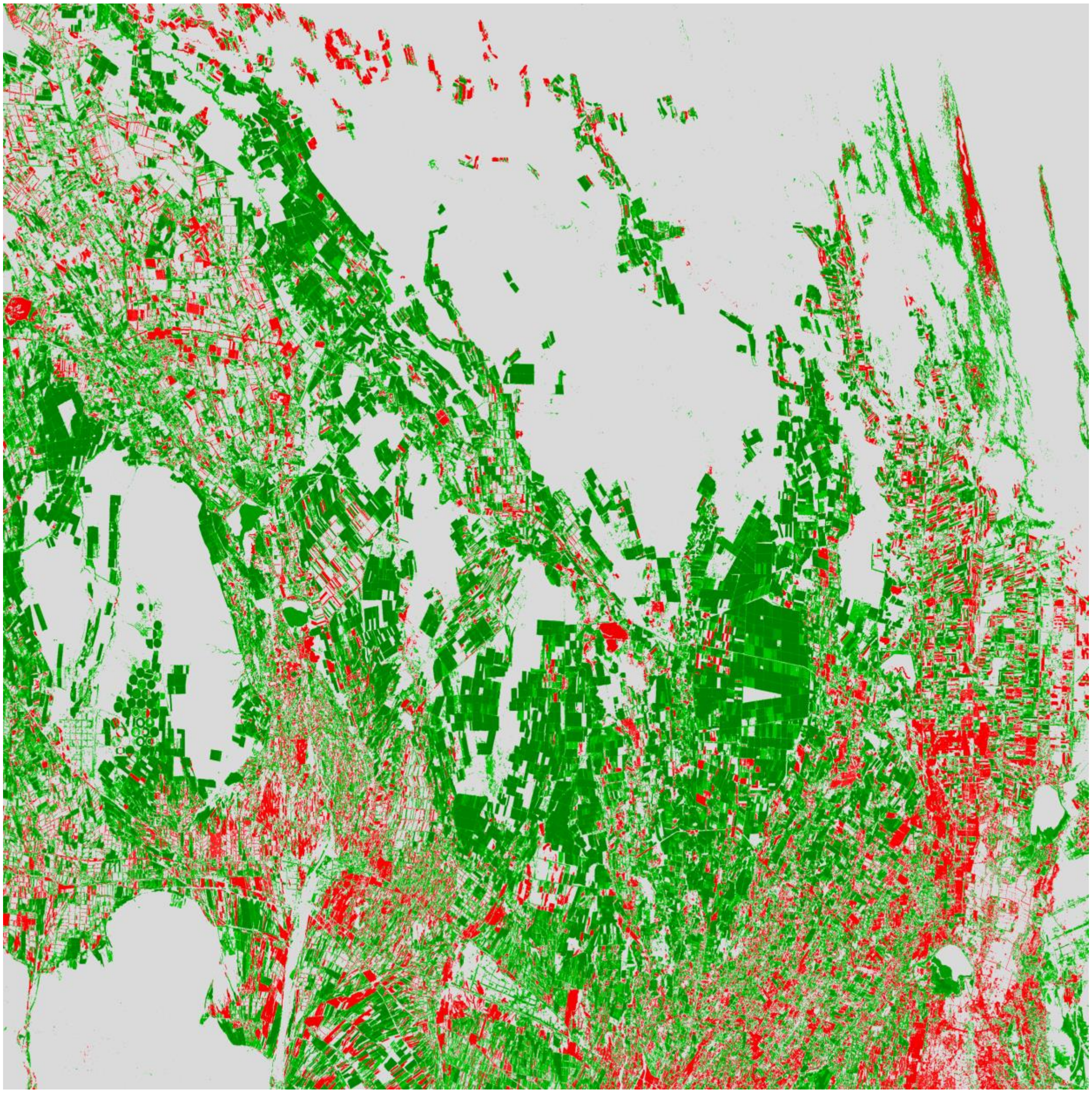

Figure 5. Map of Change Detection in NDVI from 2002-2017 of Agriculture in Xinjiang, China. Created using K Means Clustering.

Legend:
High Vegetation Loss (Dark Red)
Medium Vegetation Loss (Med Red)
Slight Vegetation Loss (Light Red)
No Change (Gray)
Slight Vegetation Gain (Light Green)
Medium Vegetation Gain (Med Green)
High Vegetation Gain (Dark Green)

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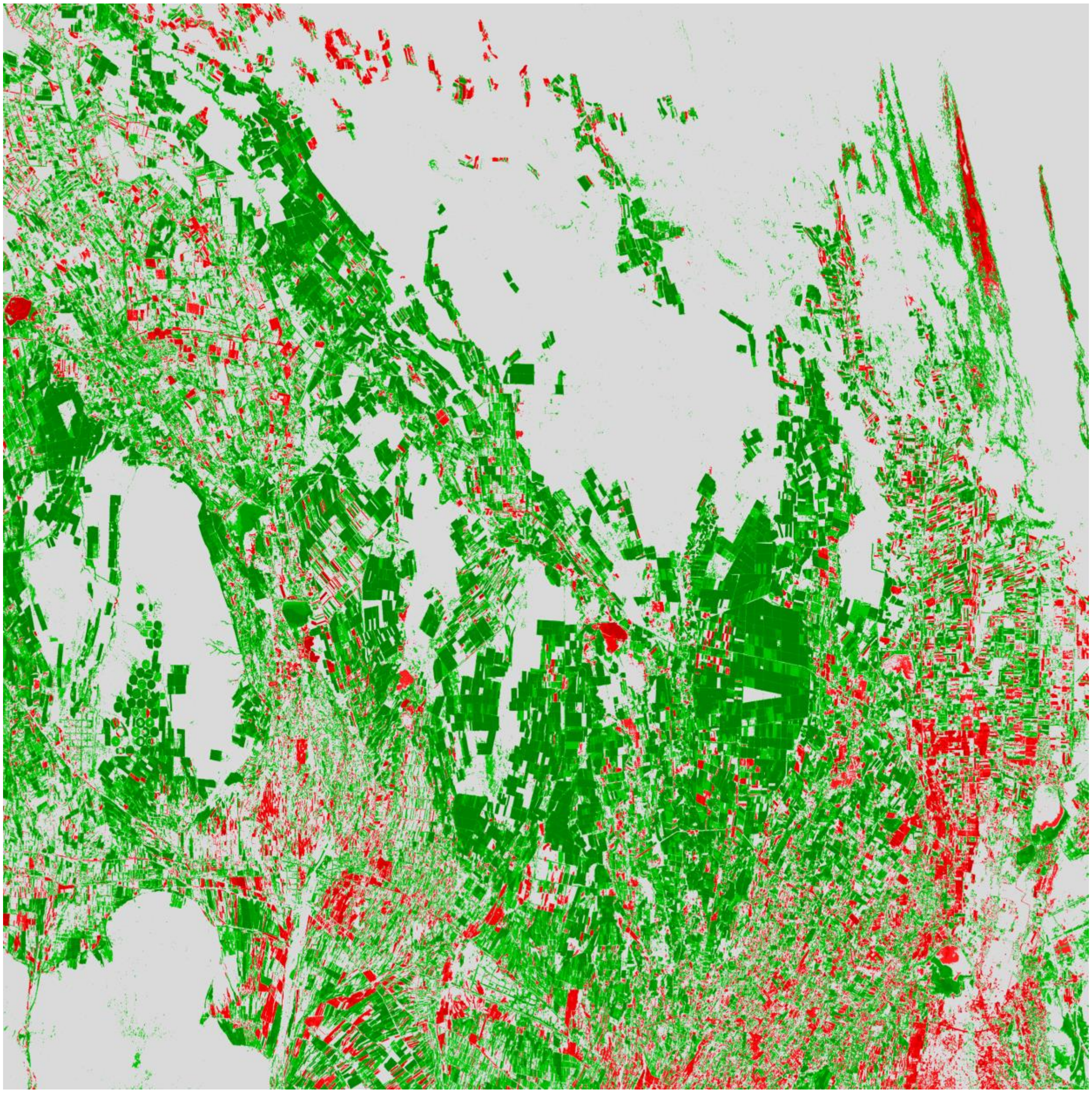

Figure 6. Map of Change Detection in NDVI from 2002-2017 of Agriculture in Xinjiang, China. Created using Image Differencing.

Legend:
High Vegetation Loss (Dark Red)
Medium Vegetation Loss (Med Red)
Slight Vegetation Loss (Light Red)
No Change (Gray)
Slight Vegetation Gain (Light Green)
Medium Vegetation Gain (Med Green)
High Vegetation Gain (Dark Green)

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Discussion

Overall, both unsupervised multi-date change detection methods (Figures 5 & 6) were highly successful.

Both the K Means and Image Differencing Maps produced very similar results, accurately and effectively capturing land cover changes on multiple levels. As a result of this analysis, these maps can be used by farmers to evaluate their farm's expansion and intensification in effort to grow crops in the most efficient means possible.

Unsupervised multi-date image stacking has proven useful when detecting change in terrestrial environments because it is an exploratory data tool that finds classes the analyst was not thinking about, and it produces a Thematic Map right away.

However, despite these advantages, there were some difficulties and confusion that occurred during the process. Often times when performing unsupervised multi-date change detection methods, small clusters can be difficult to identify and label, mixed clusters can never be separated, and lastly labeling and grouping cluster can be very tedious and time consuming.

Along with these disadvantages, differences in reflectance's between the two separate images created some confusion, resulting in both the K Means and Image Differencing classifiers to produce questionable results when determining if a land cover had *Slight Vegetation Gain* or *No Change* in certain situations.

When dealing with the K Means method, it took multiple attempts of running the classifier to finally produce clusters that would all appear on ENVI. After some experimentation of changing the Change Threshold and Iterations, the final output produced the best results.

In the end, the maps produced by the K Means and Image Differencing Methods are above satisfactory and can be used to help the problems of agriculture, and over population.

Works Cited

Zabel, F., Delzeit, R., Schneider, J. *et al.* Global impacts of future cropland expansion and intensification on agricultural markets and biodiversity. *Nat Commun* **10**, 2844 (2019) Received 14 November 2018, Accepted 30 May 2019 Published 28 June 2019 https://doi.org/10.1038/s41467-019-10775-z