Analysis the Impacts of Mississippi River Flooding in 2010

Introduction

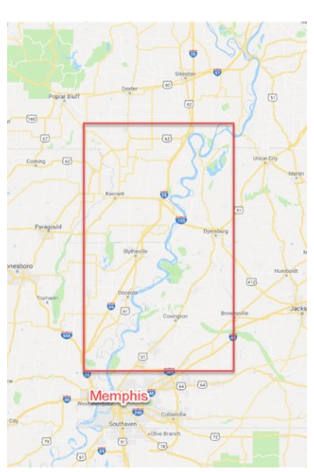
The Mississippi River is the largest river in North America, draining about 41% of the whole United States and ranking seventh in the world for river discharge. The Mississippi River plays an important role in economic and environmental field in the United States, and the government has taken long-term federal efforts to understand, predict, and manage flooding along its sides since 19th century.

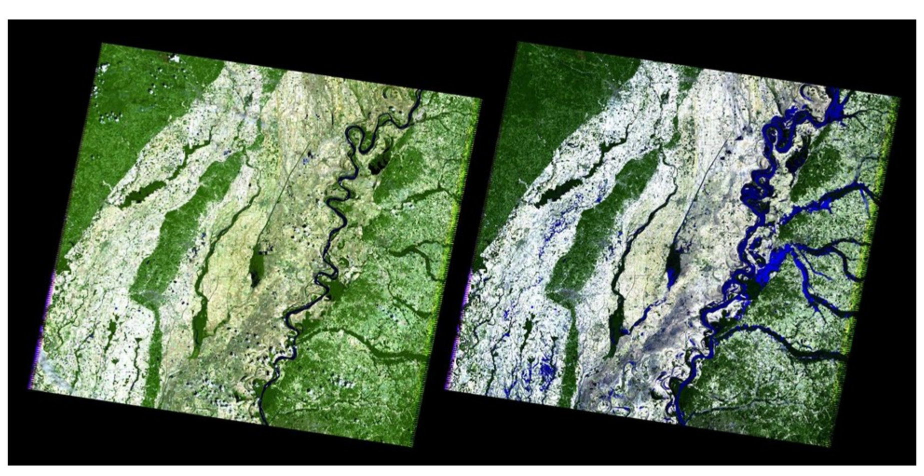
This project focuses on the flooding of Mississippi River on May 2nd, 2010, which is due to the record-breaking rainfall from severe storms on May 1st and 2nd , 2010, affected the Mississippi River along the state borders of Tennessee, Kentucky, Arkansas and Missouri. The flooding cause many damage to the urban areas as well as the natural areas. So it is necessary to analysis the flooding for people to better predict and manage flooding in the future. Remote sensing plays an important role in analyzing Mississippi River flooding, even the climate change and environment monitoring.

This project is going to analysis the impacts of Mississippi River flooding in 2010 near Memphis, Tennessee, to evaluate the level of river flooding and its damage to the surroundings, such as urban areas, agricultural areas and natural areas. Because better understanding the impacts of river flooding before is a good way to deal with similar issue in the future.

Data

Research Area





Mississippi River flows from north Minnesota to the south Gulf of Mexico. This project focuses on the Mississippi River flooding area near Memphis, Tennessee, which is marked by the red rectangle in the picture above. On May 1 and 2, 2010, there were several heavy storms which caused the flooding since then. And both data are acquired from USGS Earth Explorer and are both Landsat 5 as well as level 1. The image on the left was acquired on April 21th, 2010, while the other one was acquired on May 7th, 2010.

Methodology

1) Data Preparation

Because those data are both acquired by Landsat 5 and both level 1 data, and I have checked them in ENVI and found that they are matched well. So the Geometric Correction and Registration are unnecessary. And my first step is using the Resize tool in ENVI to make both images at the same size and only focus on the river part.

2) Change Detection

For the change detection method, I apply the following formula in the Band Math tool in ENVI:

float(b1)-float(b2) *(Formula 1)*

This formula is used to calculate the difference of the same band of two images. And I use all bands as the parameter of the change detection formula, where *b1* refers to the image of May 7th, 2010 and *b2* refers to the image of April 21th, 2010.

Besides, near-infrared imagers are especially effective, because the near-infrared spectral bands are strongly absorbed by water, yet reflected by land. So that I apply the Band 4 as the parameter for the Raster Color Slice method.

3) Classification

Classification is a useful tool in ENVI, which could distinguish different land cover types. In this case, I am interested in the river flooding area and the classification tool is used to determine the change of river area during the flooding.

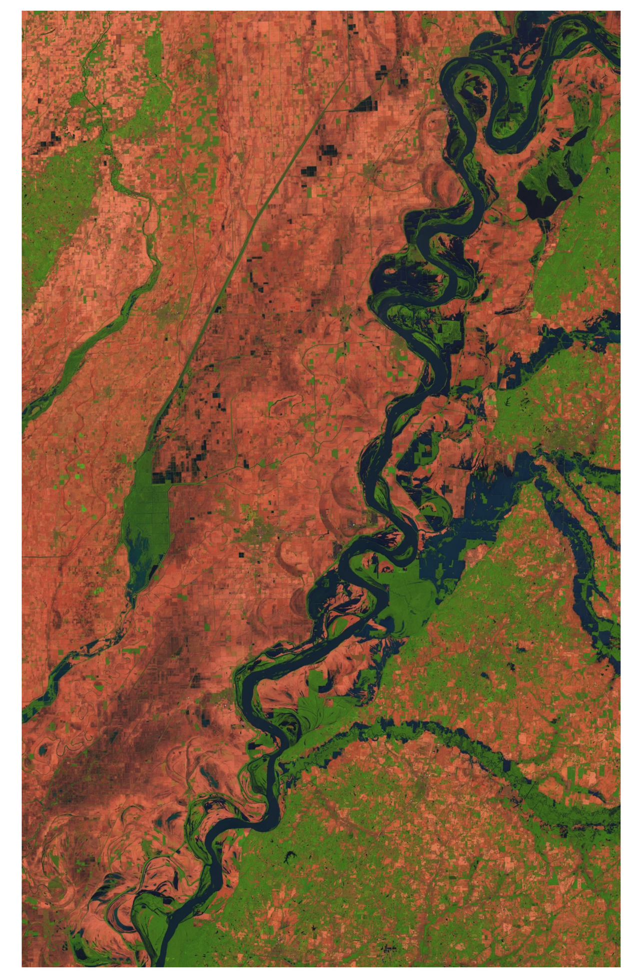
Based on the original image, there are approximately 5 major classes, including river, vegetation, two different types of soil and urban areas. In that case, I use the Minimum Distance Classification in Supervised Classification type to run the classification. Prior to the classification, the Region of Interest is used to sampling different classes. After classification, Class Statistic in Post classification tool is used to calculate the total pixels, percentage and areas of each class. Then I can describe the difference of class statistic of each image.

Post classification tools also provide the confusion matrix analysis for people to evaluate the accuracy of the classification. And the ground truth images from Google Earth are necessary to run the confusion matrix.

Results

False Color

Before

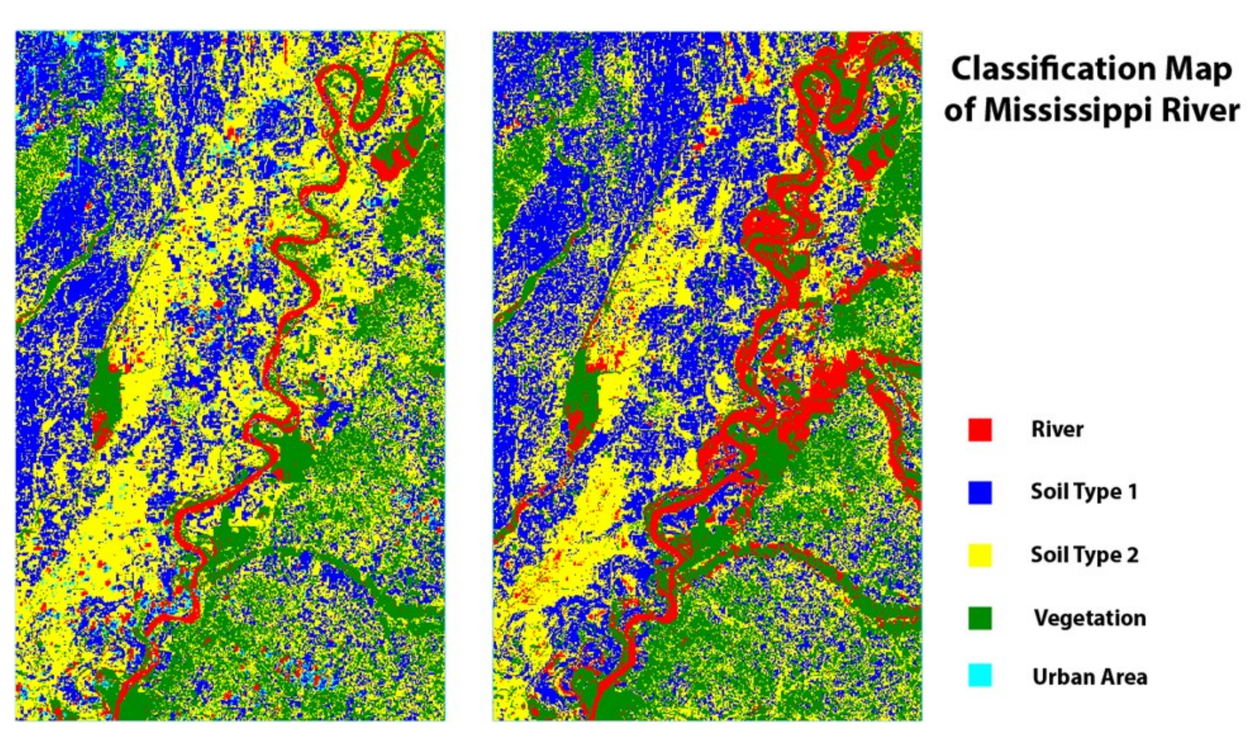


During

I have loaded the images to false color composition (5, 4, 2), which is good for detect the river, vegetation and bare soil separately. It's easy to tell some flooding patter from the false color map, and the change detection tool is used to provide more convincing evidence.

The flooding is quite obvious based on the "Before" and "After" images, when we zoom in to the river part. In the change detection raster color slice image, I apply the threshold of the colors. Because most of the values are clustered around 0 and they are considered unchanged. And the shape of river could be identified. The blue area shows mainly the flooding area, which is somehow decreasing in Band 4, since the vegetation is inundated by the river. And those light yellow areas are some clouds in one of the images, but not appear in the other. And those red areas seem to be bare soil with more rain water and more reflection in near-infrared.

Classification

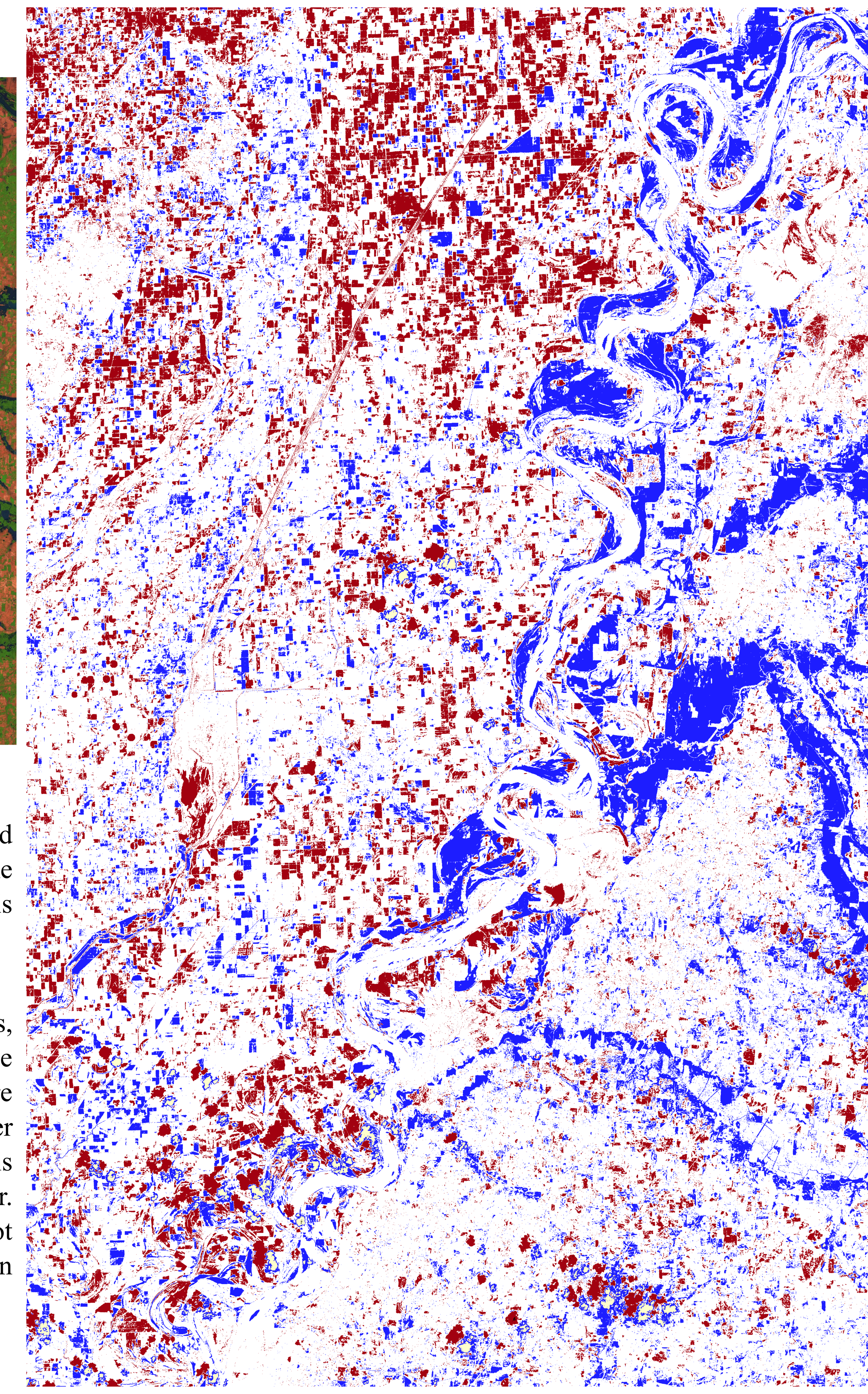


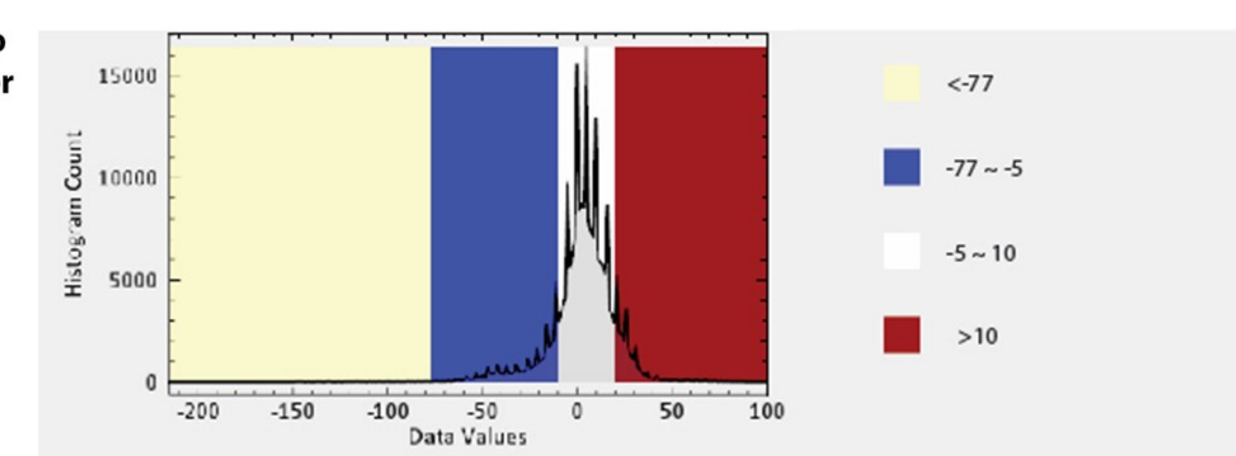
As for the classification map of Mississippi River before and during flooding, the Minimum Distance Classification is not bad in general, since it almost distinguish each classes, especially the shape of river. As we can compare the two images before and during the flooding, the red area, which is the river class, appears more in the "during" image. So that the flooding can be identified obviously in the image. Besides, there are some changes of different soil types and vegetation. This may results from the heavy rain storms, which left more rain water to the soil and vegetation and caused some differences in remote sensing images.

As we can identified from the Table below, especially the statistic of river, the increasing of percentage, pixel number and area are really obvious. The flooding area is double during the flooding, which could be considered as a serious flooding and has left huge damage. In addition, the increase in soil type 1 and vegetation may result from the heave rain storms, which brought more rain water and caused the change in spectrum of those land cover types. And the decrease in soil type 2 and urban area are probably the consequence of flooding, which inundated those areas.

	Before			During		
Class Name	Percentage	Pixel	Area (Acres)	Percentage	Pixel	Area (Acres)
River	5.32%	812,731	180,747.18	11.56%	1,764,182	392,344.98
Soil Type 1	28.96%	4,419,979	982,980.54	31.41%	4,795,340	1,066,458.89
Soil Type 2	41.92%	6,398,322	1,422,953.82	32.83%	5,012,204	1,114,688.32
Vegeta-tion	21.84%	3,333,683	741,393.91	24.13%	3,682,654	819,003.26
Urban Area	1.96%	300,431	66,814.31	0.07%	10,766	2,394.30
Total	100%	15,265,146	3,394,890	100%	15,265,146	3,394,890

Change Detection





These false color images were created by combining infrared, near infrared, and green wavelengths of light observed by the TM (bands 5, 4, and 2, respectively). In the change detection map, river is shown as dark blue, healthy vegetation is green, bare fields and freshly exposed soil are brown, and concrete is grey.

Accuracy Assessment

The Class Statistic also comes with the spectrum of the classification. As it shows, the red one is river, the green one is vegetation and other three are soil and urban areas. The spectrum tests the accuracy of the classification and shows it is works relatively well.

Besides, the results of confusion matrix shows that the overall accuracy of the classification before the flooding is 80%, while the overall accuracy during the flooding is 84%. It may because that there are some clouds in the image of April 21th, those clouds bring some confusion to the classification and affect the accuracy. However, both two overall accuracy are not bad, which shows the results of classification are relative reliable.

Conclusion

The Mississippi River flooding in May is quite heavy and it left much damage. The combination of change detection, classification, class statistic and Google Earth provides us more analysis of the flooding that time. Remote sensing plays an important role in analyzing and monitoring the flooding. This project provides some convincing evidence to the severity of flooding, some recommendations for government to deal with the flooding and some limitations for future study.

Reference

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4. Ramsay, D. and Bell, R., 2008. *Coastal Hazards and Climate Change.* A Guidance Manual for Local Government in New Zealand. 2nd edition. Wellington, New Zealand: National Institute of Water and Atmospheric Research (NIWA) and Ministry for the Environment.

CEE189: Remote Sensing

Jiao Liu

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