Use of satellite images for surface conditions monitoring in the upper Mississippi watershed during the flood event of 2008

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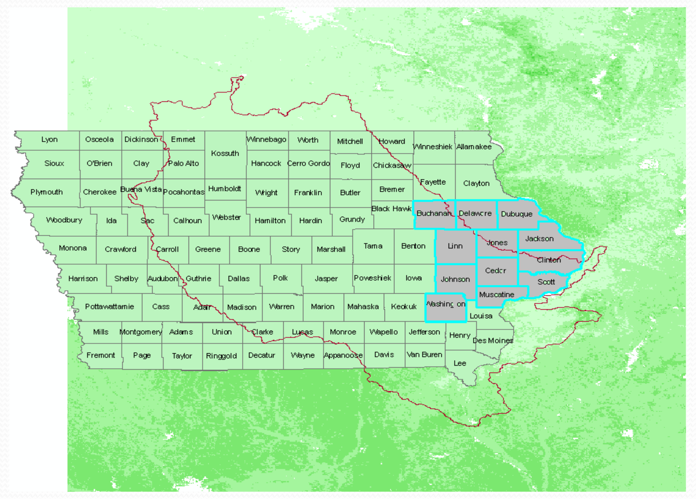
Background

The 2008 Iowa floods, which lasted from June 8,2008 to July 1, 2008, afflicted about $7 billion worth of damage.
The floods had been a result of an accumulation of climatological factors over the past half year.
Warm and Moist Winter.
April and March: string of thunderstorms as a result.
The capacity of most of the rivers in Iowa was exceeded. The Iowa River, the Cedar River, and the Skunk River along with many other local rivers all exceeded their limits which resulted in catastrophe for Iowa residents. The eastern half of Iowa, where all the major rivers flow through, was the most impacted by these floods.
The cities of Iowa City and Cedar Rapids bore the brunt of the floods. In fact, Cedar Rapids witnessed 3,900 homes inundate and 7,000 jobs lost.

Area of Interest

Figure 1.1: This is a super composition of 4 images. The large square image is 4 satellite images stitched together. The red outline is the area which was effect by the flood according to Dr. Temimi. The county map is that of Iowa. And the blue highlighted signify the most affected area.



Objectives

This study aims to detect and measure the environmental impact of these floods on the state of Iowa through remote sensing.
The study will focus on measuring the quantity and quality of vegetation growthout the state as well as examine the most affected region in the state.
The most affected region was in and around the cities of Iowa City and Cedar Rapids. We will examine it in hopes of seeing the exaggerated effects of flooding and to account for the relatively large size of the combined 4 satellite images which inadvertently includes locations which were not affected by flooding (see Figure 1.1).

MATERIALS

Data Source

- Search Engine: WIST Powered by ECHO NASA
- Satellite: Moderate Resolution Imaging Spectroradiometer (MODIS)-Aqua

Data Type

- Surface reflectance:
  - measures land reflectance, undoubtedly caused in large part by flood water on land, to visually comprehend the extent of the flooding.
- Leaf Area Index (LAI)
  - Measures quantity of vegetation on the ground to see greenery levels throughout the year
- Normal Difference Vegetation Index (NDVI)
  - measures the photosynthetic capacity of the vegetation by measuring the data in the red and near-infrared portions of the spectrum
  - allows the separation of healthy, unhealthy, and dead vegetation giving us a better sense of the vegetation value as compared to LAI.

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PROCEDURE

Surface reflectance:

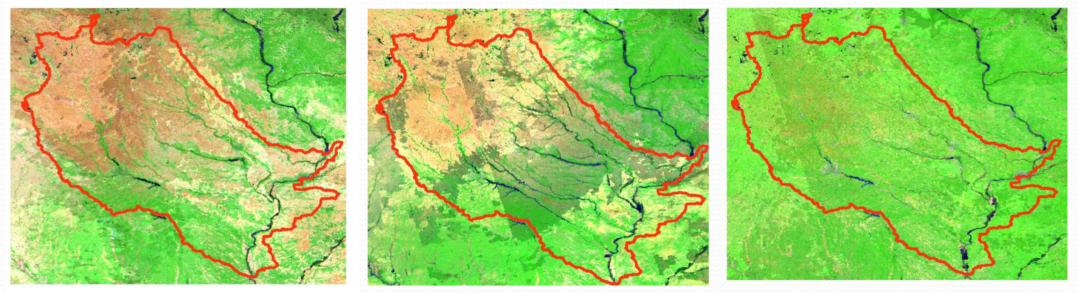
1. First, download data using WIST.
2. Next, use ENVI software
   a. First, to mosaic (stitch) the 4 satellite images together to create one image containing the whole area of interest.
   b. Then, to assign a combination of bands to the three primary colors; in our case it is the 7-5-3 combination to Red, Green, and Blue respectively. This gave a natural-like rendition and made clear the extent of the flooding by readily distinguish between low-lying water and land.
   c. Finally, to convert the images' format from an .hdr to .hdf to .geotiff.
3. Finally, use ARCMap to exploit the .geotiff image to better examine the effects and extent of the flooding.

LAI & NDVI:

1. First, download data using WIST.
2. Next, use MODIS Reprojection Tool
   a. First, to convert the images' format from an .hdr to .hdf to .geotiff.
   b. Next, to change the Geo Reference of the data from WGS84 to NAD83.
   c. Finally, to mosaic the 4 images together to produce one image containing the whole area of interest.
3. Then, use ARCMap
   a. First, to multiply the data by factors of .1 for LAI and .0001 for NDVI via the raster calculator under spatial analyst.
   b. Next, to exclude data points 24.9-25.5 for LAI and -.3 for NDVI.
   c. Then, to calculate the monthly mean values of the data for both years.
   d. Next, to reclassify the data in a light green spectrum in order to better our ability to visually comprehend the satellite image.
   e. After, to 'clip' (crop) the image to focus in on the most affected area.
4. Repeat step 3a – 3d.
5. Finally, use MatLab to plot the monthly averages for the two years on single plots for both whole and most affected areas.

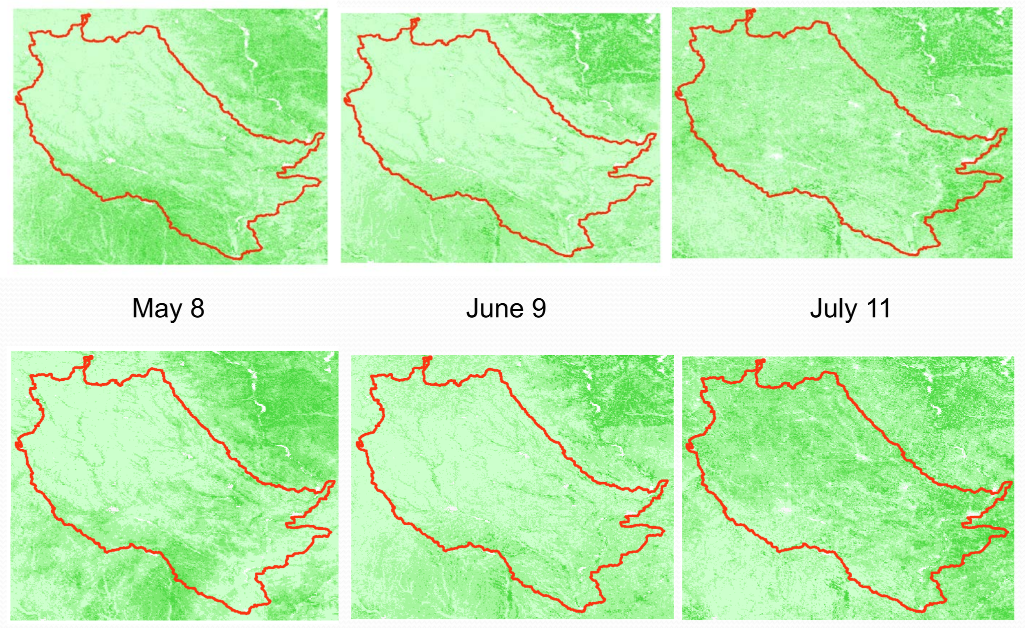
RESULTS

Surface Reflectance



May 8, 2008 | June 9, 2008 | July 11, 2008

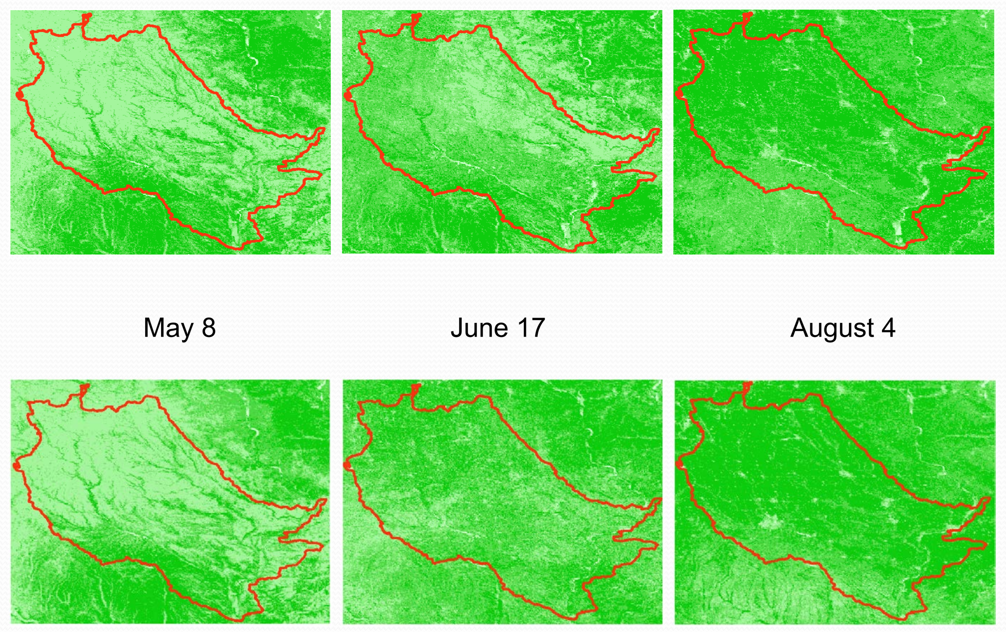
LAI



2008: May 8 | June 9 | July 11

2007

NDVI



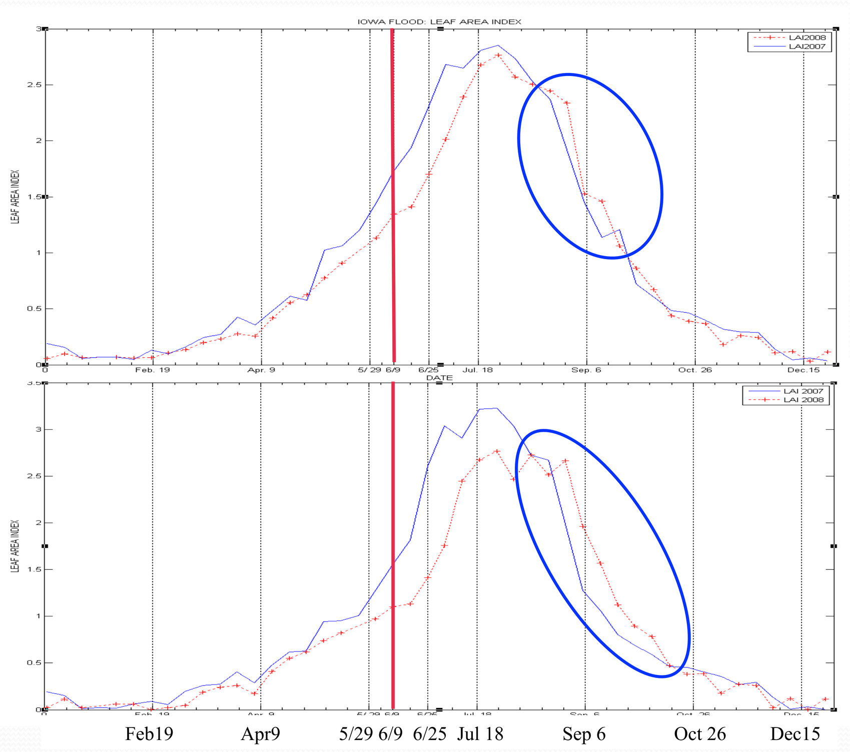
2008: May 8 | June 17 | August 4

2007

Time Series LAI

Whole Area

Most Affected Area

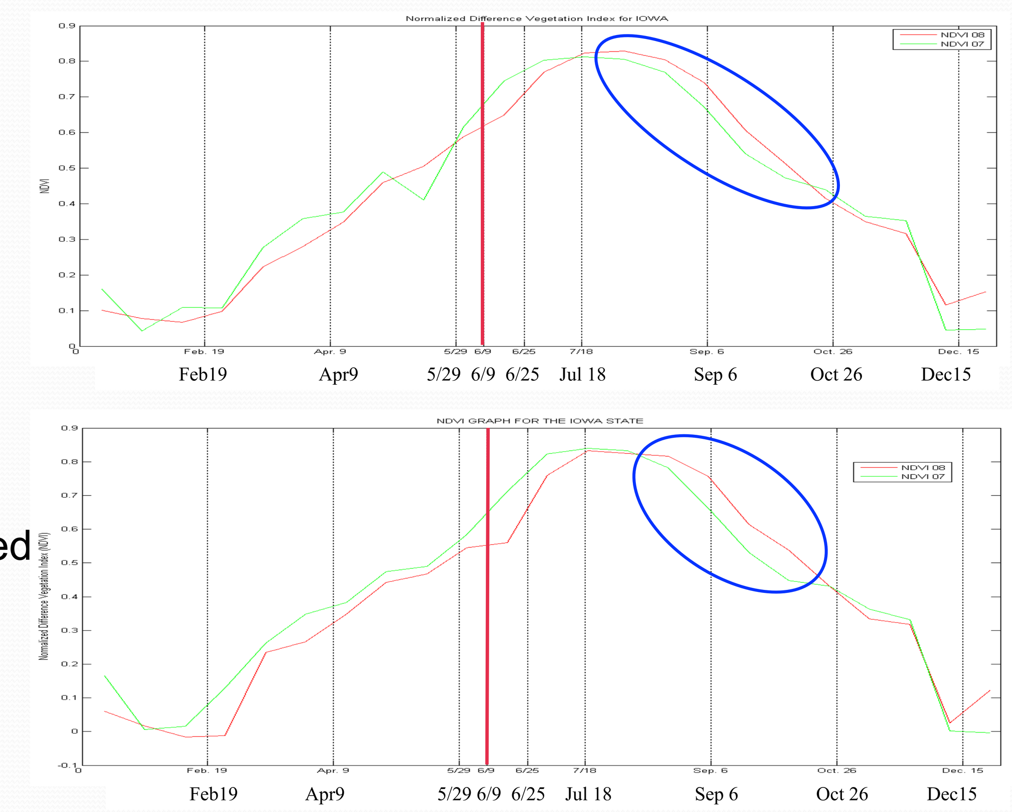


Legend:
2007
2008
June 9

Time Series NDVI

Whole Area

Most Affected Area



Legend:
2007
2008
June 9

OBSERVATIONS

- Surface reflectance data revealed that the dates of May 8, 2008, June 9, 2008, and July 11, 2008 were ideal for visualizing the effects and extent of the flooding.
- These images indicated that the water levels had increased rapidly on June 9 and then within the next week had begun stabilize and even decrease in prevalence to a certain extent. By July 1 the water levels were back to pre-flood levels.
- Surface Reflectance indicated that there was a increase in vegetation growth after the flood.
- LAI confirmed the previous observation in scientific terms by isolating vegetation, but showed the increase was relatively small as compared to 2007's.
- The year long LAI time series corroborated what we knew already, that the trend lines for 2008 and 2007 LAI averages were almost identical prior to the flood and then diverged accordingly about 10 days before the flood, but also showed that after the month of July the average monthly values were higher for 2008 than for 2007.
- Due to the unavailability of data on certain dates and to further test our findings of the post-July effect on vegetation in 2008, we choose the days of May 8, June 17, and August 4 to best represent the pre-, during, and post flood conditions for NDVI data.
- NDVI data corroborated previous findings even though it differentiated between healthy, unhealthy, and dead vegetation.
- All graphs and images for the most affected region substantiated what was found on the larger scale but demonstrated each effect of the flooding in a exaggerated fashion.

CONCLUSIONS

This study has analyzed the vegetation status in Iowa over the course of two years using three different types of data: surface reflectance, leaf area index, and normalized difference vegetation index. All indicated that prior to the flood, the vegetation levels throughout Iowa were within the range of natural variation. It was also revealed that, during the flood period, vegetation levels in 2008 were at a lower level than those of 2007. Most importantly the data indicated that, for the whole area as well as the most affected area, vegetation levels in 2008 were greater than those of 2007 after the month of July. This is unexpected due to the fact that flooding is usually looked upon as a destructive force rather than a regenerative one. However, these findings become more plausible when we factor in the nutrients and organic matter which floods bring onto land and thus allow for floods to be looked upon as replenishing agents for the soil.

FUTURE RESEARCH

- Analyze 2006 data
- Focus on AMSR-E passive microwave data; soil moisture

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