Development of a Near-Real Time Hail Damage Swath Identification Algorithm for Vegetation

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Introduction

- Severe thunderstorms that bring damaging winds and large hail can cause significant damage to surface vegetation, especially agricultural crops. Satellite imagery can used to identify and gauge the severity of damage.
- Damage to the crops become identifiable when the vegetation begins to stress or is no longer visible to the sensors. This can affect derived vegetation indices as well as local temperature anomalies
- Changnon worked extensively in the 1960s and 1970s on the identification of hailswaths and their impacts upon agricultural areas. His work attempted to quantify the damage to crops using aerial surveys as well.
- Additional previous work involving using satellite imagery for identifying hail streaks, has been successful. The observed streaks all appeared to have common shape characteristics between them, which made the easily identifiable using satellite imagery.
- One of the main themes that is constant throughout all the previous work is the that the detection is manually done. Manual detection can take up valuable time and resources. By developing an automatic detection algorithm, time and resources no long become an issue. Automatic detection also allows for additional datasets to be easily integrated into the detection process.

Data & Methodology

- Aboard the polar orbiting Aqua and Terra satellites, the Moderate Resolution Imaging Spectrometer (MODIS) has been frequently been used in identifying hail swaths in the 2000s. In order to try and obtain as many observations as possible, the **Visible Infrared Imaging Radiometer Suite (VIIRS)** data was used. Using VIIRS imagery prepares the algorithm for the Joint Polar Satellite System (JPSS) era.
- MESH data is used to validate areas of potential damage and look for correlations between radar estimated hail size and vegetation change.
- Simple vegetation differencing has been frequently used, but concerns of noise and simplicity in evaluating significant short-term vegetation changes, were the reasons to explore other techniques

Vegetation Health Index (VHI)

- The Vegetation Health Index (VHI) is an index that was developed for drought monitoring by observing vegetation stress. VHI is a combination of three equations that is based on Normalized Difference Vegetation Index and land surface temperature.

- VHI along with Vegetation Condition Index (VCI) and Temperature Condition Index (TCI) are the equations, that are generally based on multiyear minimums and maximums. In order to use for hail swath detection, the equations have been modified from multiyear maximums, minimums and means, to 14 day percentiles.

References

Changnon, S. A., and N. A. Barron, 1971: Quantification of Crop-Hail Losses by Aerial Photography. *J. Appl. Meteorol.*, **10**, 86–96, doi:10.1175/1520-0450(1971)010<0086:QOCHLB>2.0.CO;2.

Gallo, K., T. Smith, K. Jungbluth, and P. Schumacher, 2012: Hail Swaths Observed from Satellite Data and Their Relation to Radar and Surface-Based Observations: A Case Study from Iowa in 2009. *Weather Forecast.*, **27**, 796–802, doi:10.1175/WAF-D-11-00118.1.

Otsu, N., 1975: A Threshold Selection Method from Gray-Level Histograms. *Automatica*, **11**, 62–66.

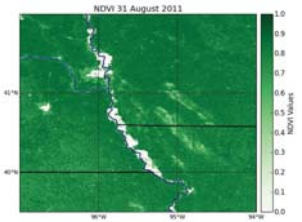

Figure 1. A single day NDVI image from 31 August 2011.

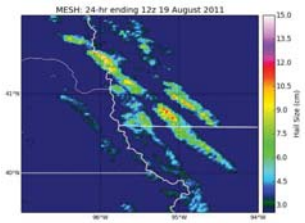

Figure 2. Maximum Expected Size of Hail (MESH) from 12 UTC 18 August 2011 through 12 UTC 19 August 2011.

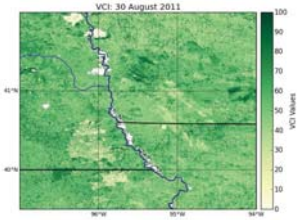

Figure 3. Vegetation Composite (VCI) valid on 31 August 2011

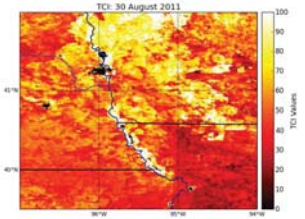

Figure 4. Temperature Composite (VCI) valid on 31 August 2011

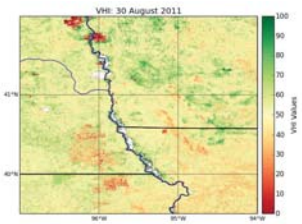

Figure 4. Vegetation Health Index (VHI) valid on 31 August 2011.

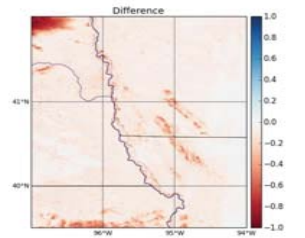

Figure 6. Difference of Vegetation Health Index (VHI) valid on 31 August 2011 from 18 August 2011

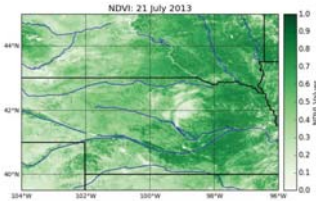

Figure 7. Single day VIIRS NDVI image taken on 21 July 2013

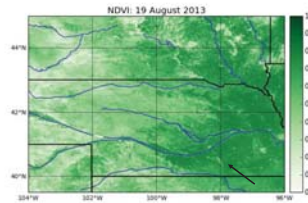

Figure 8. Single day VIIRS NDVI image taken on 19 August 2013

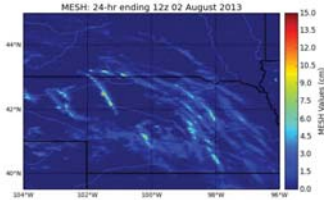

Figure 9. MESH composite valid from 12 UTC 01 August 2013 through 12 UTC 02 August 2013

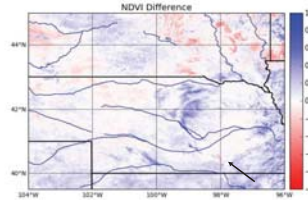

Figure 10. Difference of VIIRS imagery

Feature Detection

- Feature detection provides another possible way of finding potential hail damage in vegetation. Many of these techniques are unsupervised.
- One of these methods is Otsu's method. This simple method focuses taking a greyscale image, clustering the pixels based on a threshold and converting the imagery to a binary image.

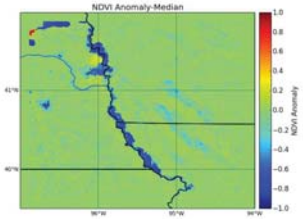

Figure 11. NDVI anomaly for 31 August 2011.

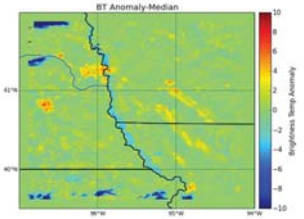

Figure 12. Brightness temperature anomaly for 31 August 2011.

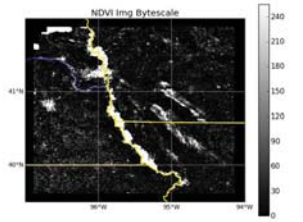

Figure 13. NDVI anomaly on 31 August 2011 that has been bytescaled.

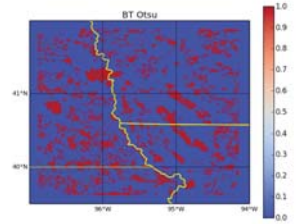

Figure 14. Brightness temperature (bytescaled) after passing through Otsu filter

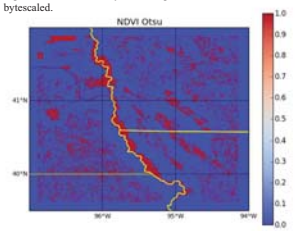

Figure 15. NDVI after passing through the Otsu filter.

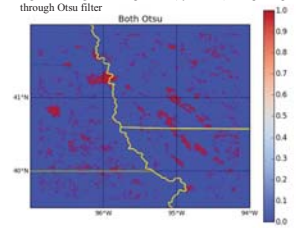

Figure 16. Combination of area that are Otsu positive in both NDVI and Brightness Temperature.

Future Work

Short-Term

- Continue to explore case studies using both VHI and Feature Detection. Modifications to for tuning the algorithm continue even to date.

- After refining the VHI and Feature detection methodology, test the algorithm in a quasi near-real time setting using previous years' growing seasons, while also determining exactly how MESH data will be used for validation..

- After testing the algorithm in a quasi near-real time setting, set up product as operational product that can be assessed through SPoRT's research to operations paradigm.

Long-Term

- After successfully demonstrating the ability to identify significant vegetation changes as result of damaging hail storms, expanding the near-real time algorithms to identify tornado tracks, wildfires and other disasters will be attempted.