Identifying Hail Signatures in Satellite Imagery from the 9-10 August 2011 Severe Weather Event

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INTRODUCTION

Severe hail causes property damage, livestock fatalities, and crop failure. However, detailed storm surveys of hail damage conducted by the National Weather Service (NWS) are not required. Current gaps also exist between Storm Prediction Center (SPC) hail damage estimates and crop insurance payouts. NASA's Moderate Resolution Imagining Spectroradiometer (MODIS) instrument can be used to support NWS damage assessments, particularly to crops during the growing season. The 9-10 August 2011 severe weather event across western Nebraska and western Kansas offers a case study for investigating hail damage signatures by examining changes in Normalized Difference Vegetation Index (NDVI) derived from MODIS imagery. By analyzing hail damage swaths in satellite imagery, potential economic losses due to crop damage can be quantified and further improve the estimation of weather impacts on agriculture without significantly increasing manpower requirements.

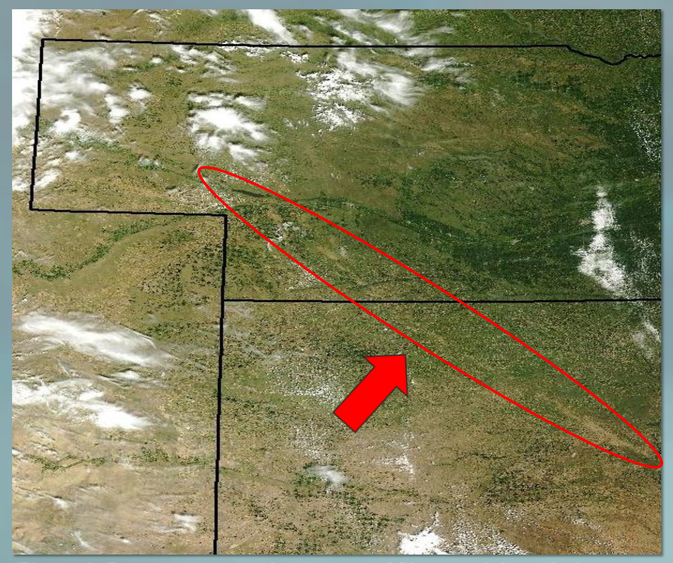

Figure 1. Post-event true color image at 250 m spatial resolution acquired from Terra MODIS on the morning of 14 August 2011. Hail damage scar is outlined in red.

METHODOLOGY

- Used MODIS satellite imagery to calculate NDVI:

$$NDVI = \frac{(R_{NIR} - R_{VIS})}{(R_{NIR} + R_{VIS})}$$

- Digitized visible hail damage in NDVI products using ArcGIS for Desktop's editor tool
- Determined data correlation between identified hail swaths, Maximum Expected Size of Hail (MESH) product, and SPC hail reports
- Developed a proxy that quantifies potential economic loss of three major cash crops affected by hail event:
  - Corn, soybeans, and winter wheat
  - Used crop acreage, yield, and prices provided by the United States Department of Agriculture Crop Data Layers

CASE STUDY RADAR IMAGERY

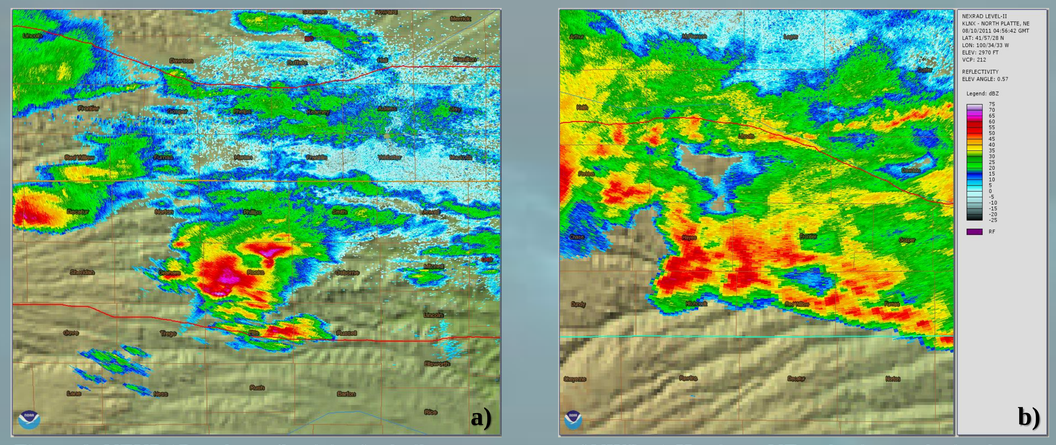

Figure 2. NEXRAD radar reflectivity for hail event courtesy of NWS: a) Hastings, NE radar image during largest reported hail size of 4.25 inches on 10 Aug 2011, b) North Platte, NE radar image on 10 August 2011.

MESH DATA & STORM REPORTS

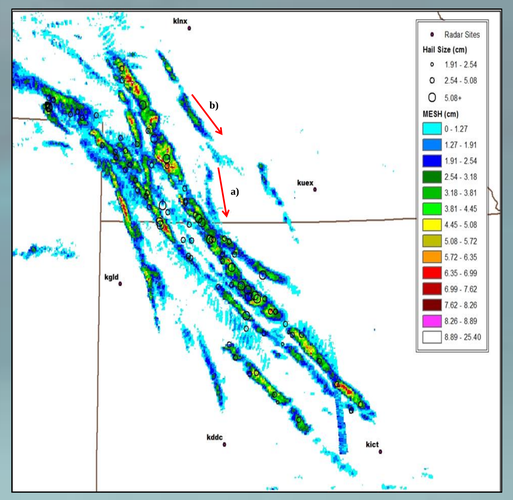

Figure 3. MESH data from NSSL Rapid Response and SPC hail reports for the 9-10 August 2011.

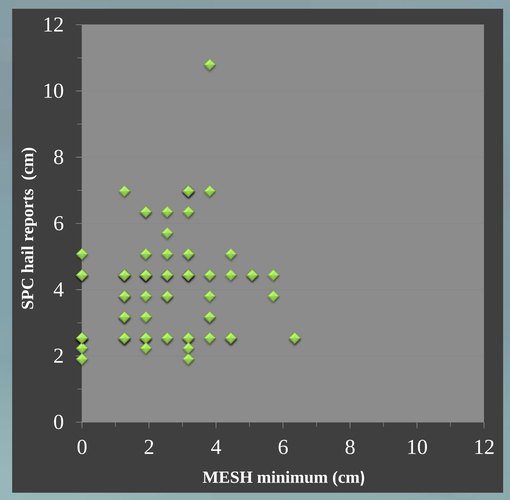

Figure 4. Minimum expected hail size versus SPC hail reports for the 9-10 August 2011.

NDVI DERIVED PRODUCTS

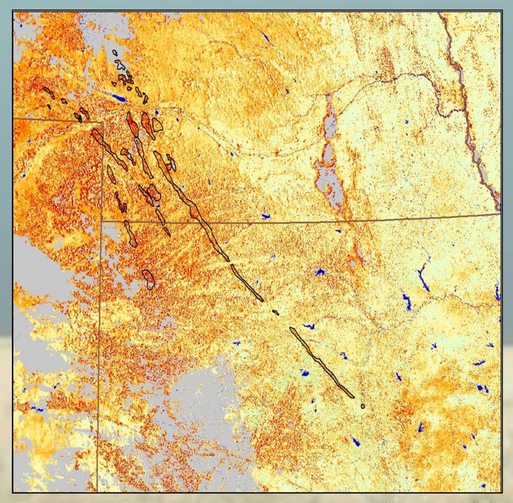

Figure 5. NDVI change based upon a difference of 13 August 2011 NDVI imagery and the previous 14-day composite. Identified hail swaths are outlined in black.

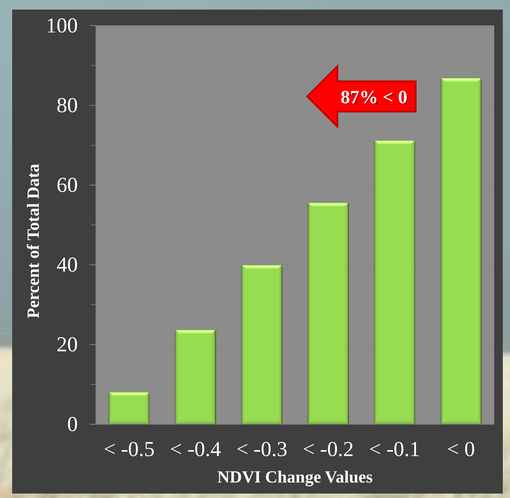

Figure 6. Cumulative fraction of NDVI change in identified hail swaths.

CROP DAMAGE RESULTS

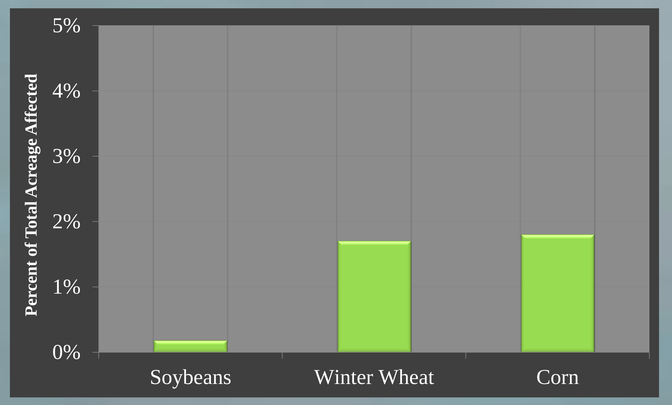

Figure 7. Percentage of total crops affected by hail event compared to total acreage.

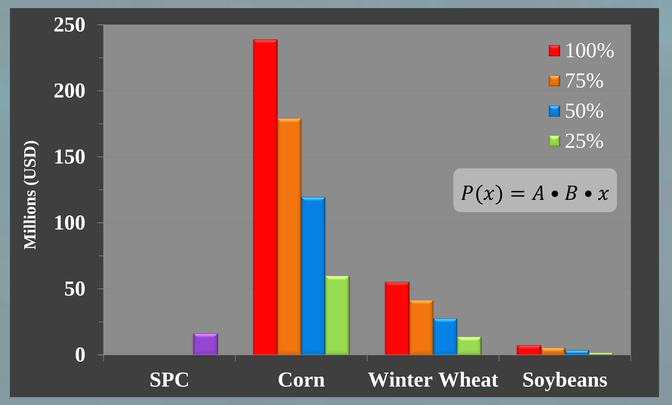

Figure 8. Projected economic losses of major cash crops (P) due to hail event damage. For derived equation, A represents the acres affected , B represents the bushels per acre, and x denotes the percentage of acres affected at varying levels of 100%, 75%, 50%, and 25% loss.

CONCLUSIONS

- Hail scars are identifiable in MODIS satellite imagery based on NDVI change, which was dominantly negative.
- Hail damage spatially correlates with SPC hail reports and MESH.
- This study developed a proxy for quantifying crop loss at varying thresholds to address the gap between SPC damage estimates and insurance payouts.

FUTURE WORK

- The damage assessment proxy created in this study could be automated across various time scales and potentially show severe weather patterns in relation to recent climate trends.
- Once automated, this damage assessment could be used to quantify hail damage losses over larger spatial and temporal scales.

ACKNOWLEDGEMENTS

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