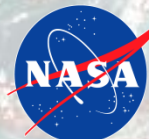# New Techniques for Tornado and Hail Damage Detection

Science Advisory Committee Meeting

26 – 28 August, 2014

National Space Science and Technology Center, Huntsville, AL

Concentration of Work

- Previous work by SPoRT (Jedlovec et al. 2006 & Molthan et al. 2013) showed the value of utilizing NASA datasets in evaluating damage as a result of severe storms

- Satellite Imagery for Damage Assessments
  - Provides additional datasets for analysis with integration into the damage assessment process
  - Single day NDVI products led to the publication of potential products to utilized in NOAA/NWS Damage Assessment Toolkit
  - High resolution commercial imagery provides great upside in additional detail and product development

- Hail Detection Algorithm
  - An algorithm that yields detection of hail damage in areas frequented by damaging hail storms
  - Working on combining data from multiple sources to validate algorithm, but also to measure impacts of detected damage.

- Main goal of work is to continue SPoRT's paradigm of research to operations. All work is concentrated on taking manual analysis to automatic products.
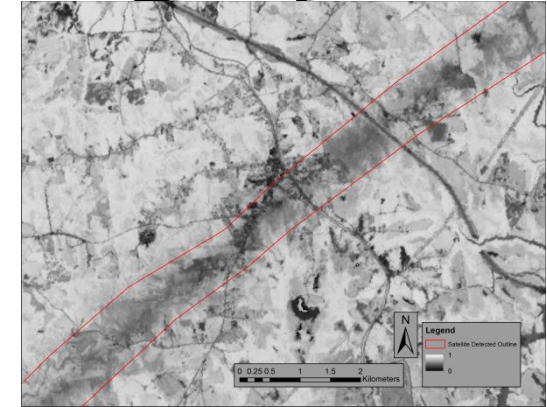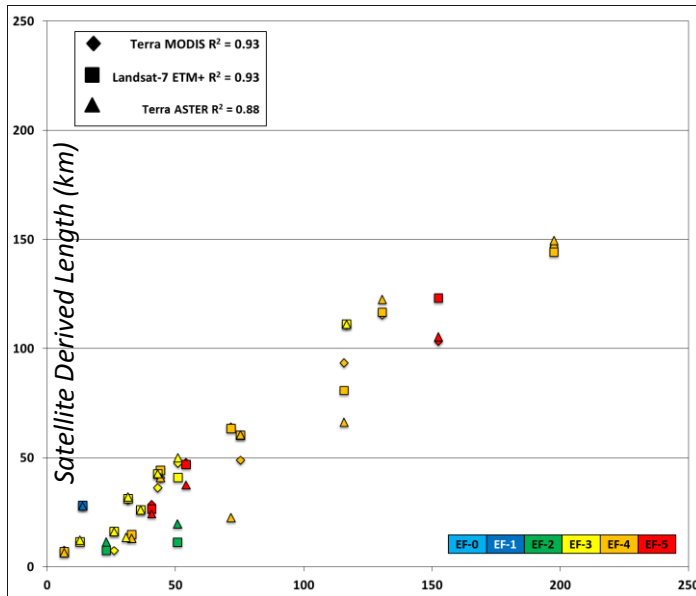
Comparison of NASA Imagery
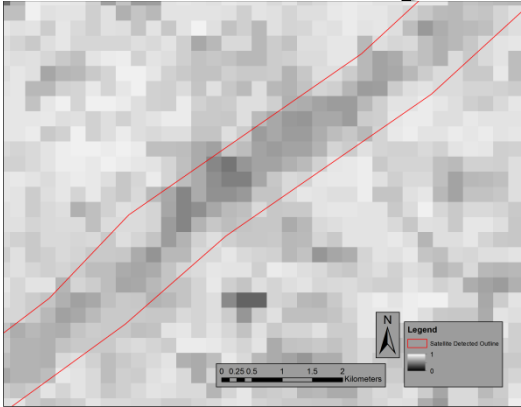
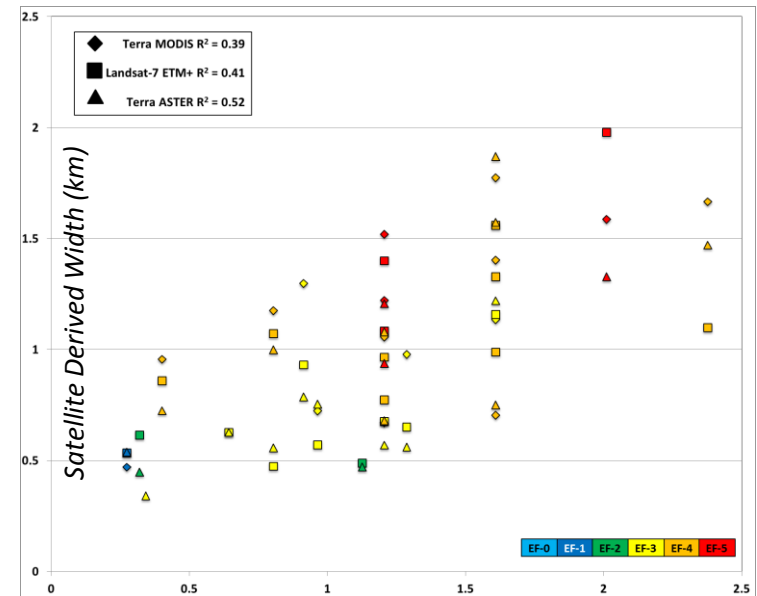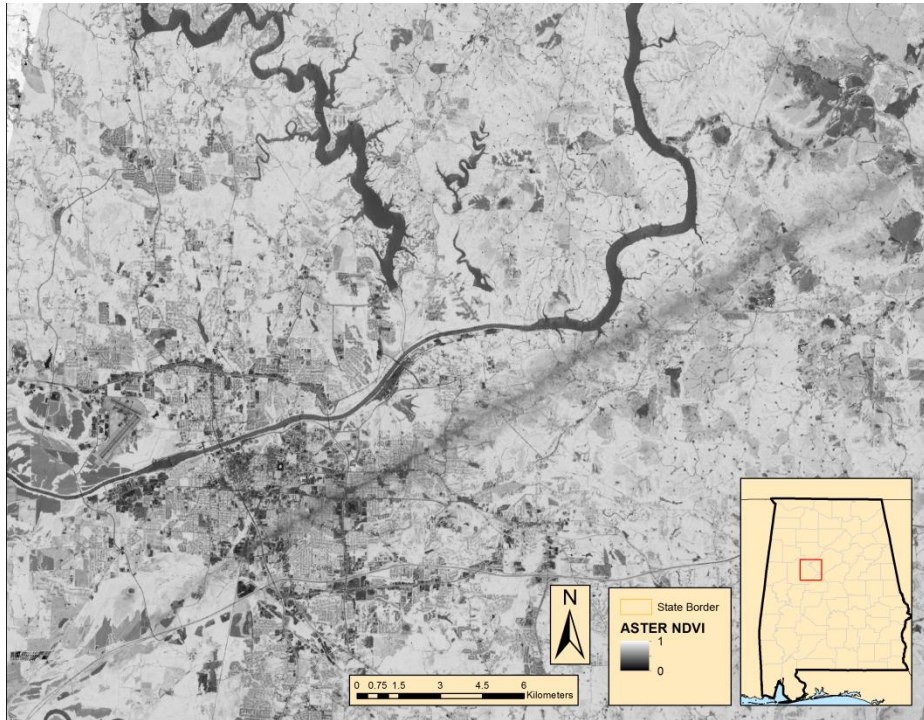*MODIS—250m*
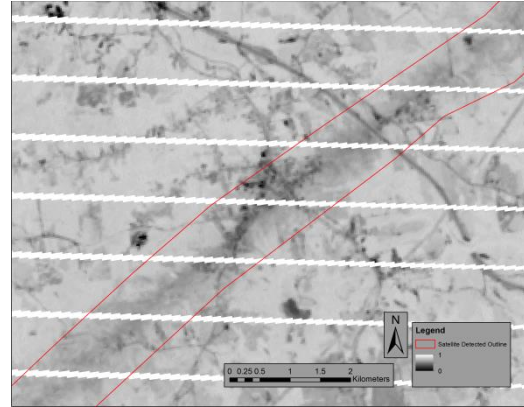
Landsat-7 ETM+—30m

ASTER—15m

*Comparisons of satellite-measured and official length and width of identified tornado damage tracks.*

Challenges of Tornado Detection

Single day ASTER NDVI imagery shows the tornado track left by the Tuscaloosa-Birmingham EF-4 tornado. The track became apparent just on the SW side of Tuscaloosa, before moving through the down. The underlying vegetation and terrain in between TUC and BMX allowed for the track to be very easily traced.
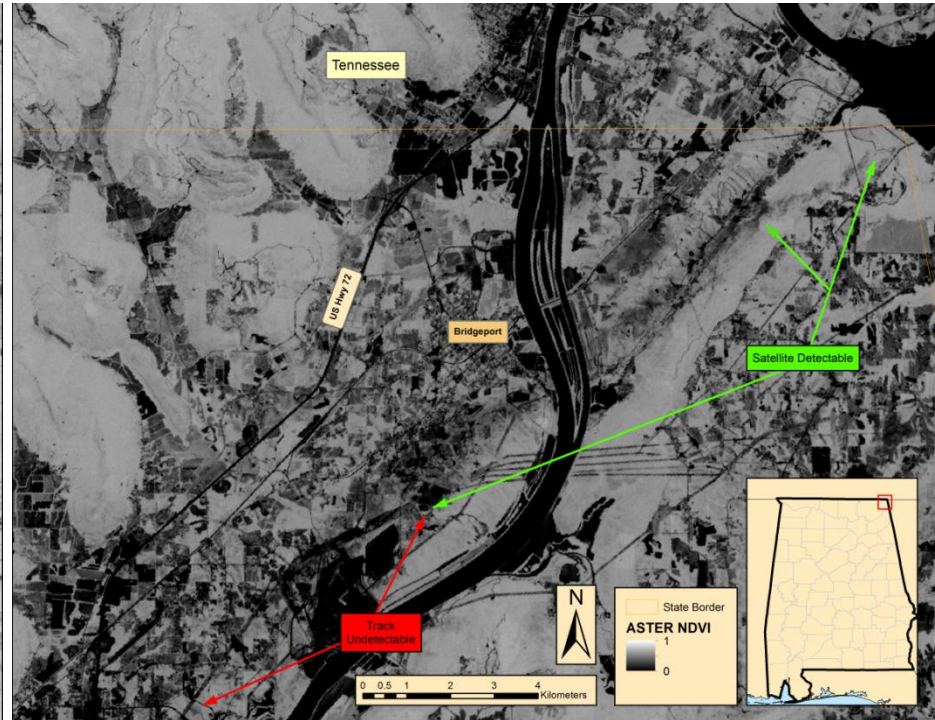
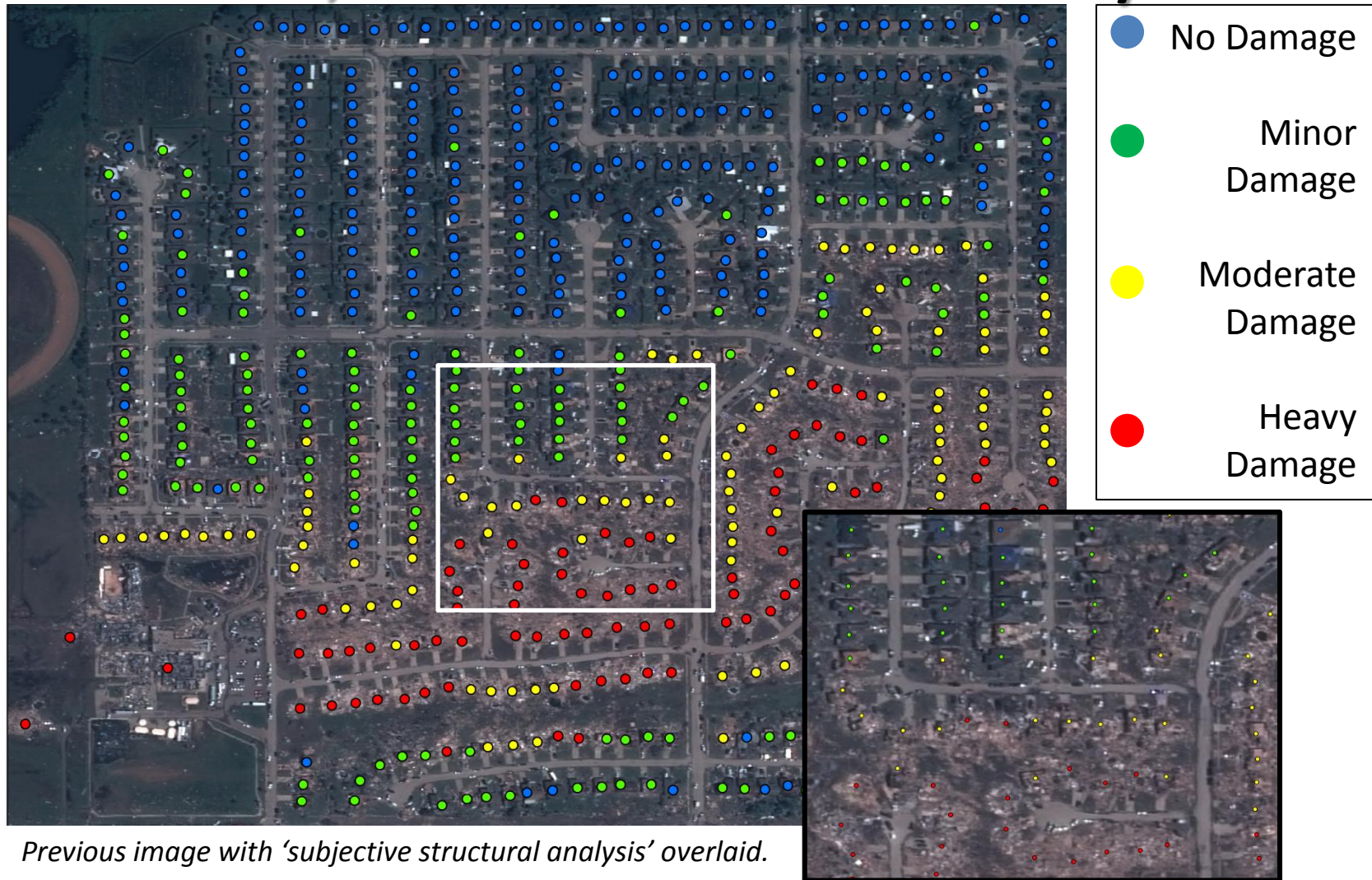*Single day ASTER NDVI imagery shows challenges of manually detecting tornado tracks over complex terrain. The Bridgeport EF-4 (above) was non detectable along the western portion of the Tennessee River, but became detectable in more uniform terrain.*

Moore, Oklahoma—20 May 2013

© CNES 2014, Distribution Astrium Services / Spot Image

Imagery acquired from Pleiades on May 22, 2013. Resolution ~0.5m.

Moore, Oklahoma—20 May 2013

No Damage

Minor Damage

Moderate Damage

Heavy Damage

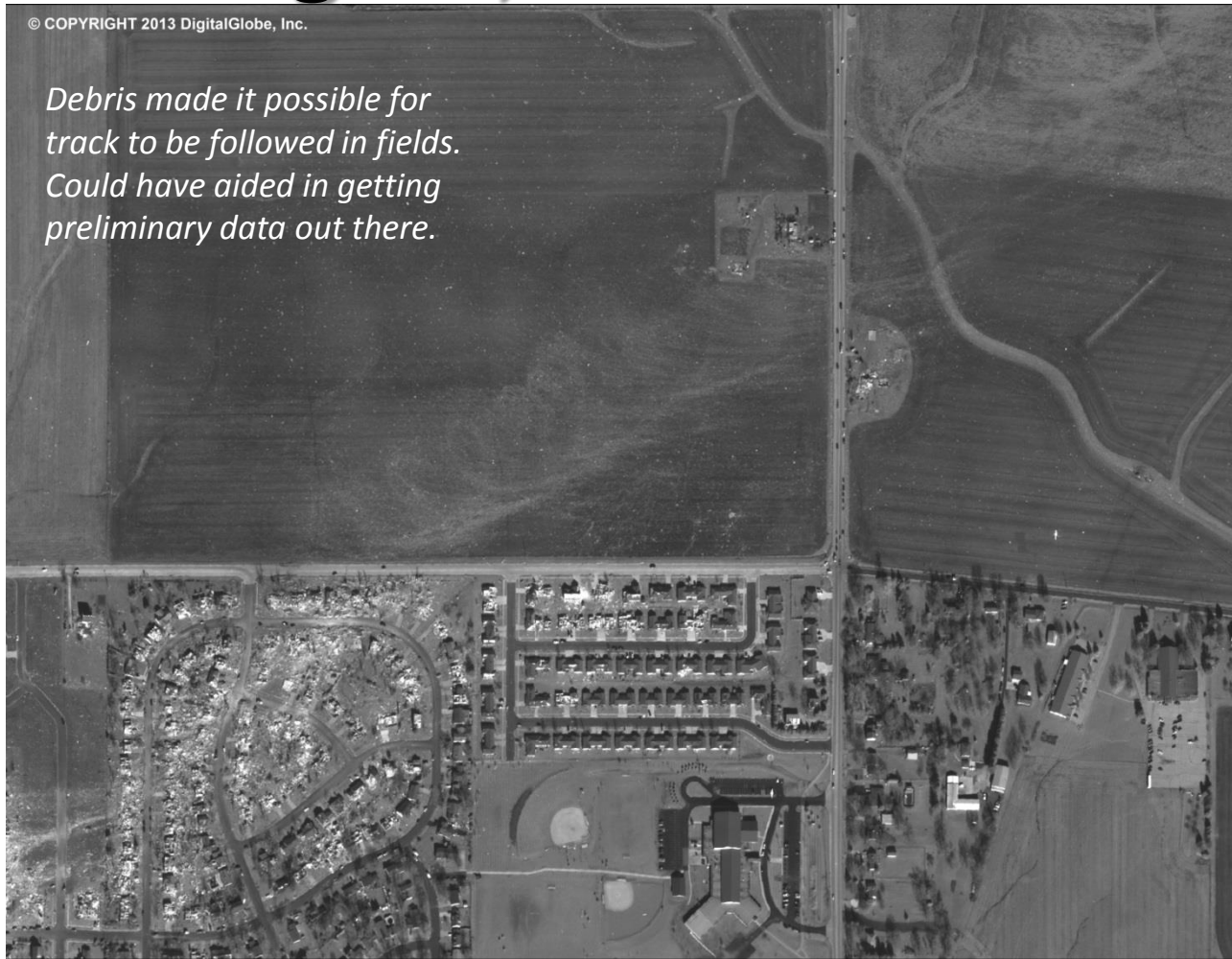*Previous image with 'subjective structural analysis' overlaid.*

Moore, Oklahoma—20 May 2013
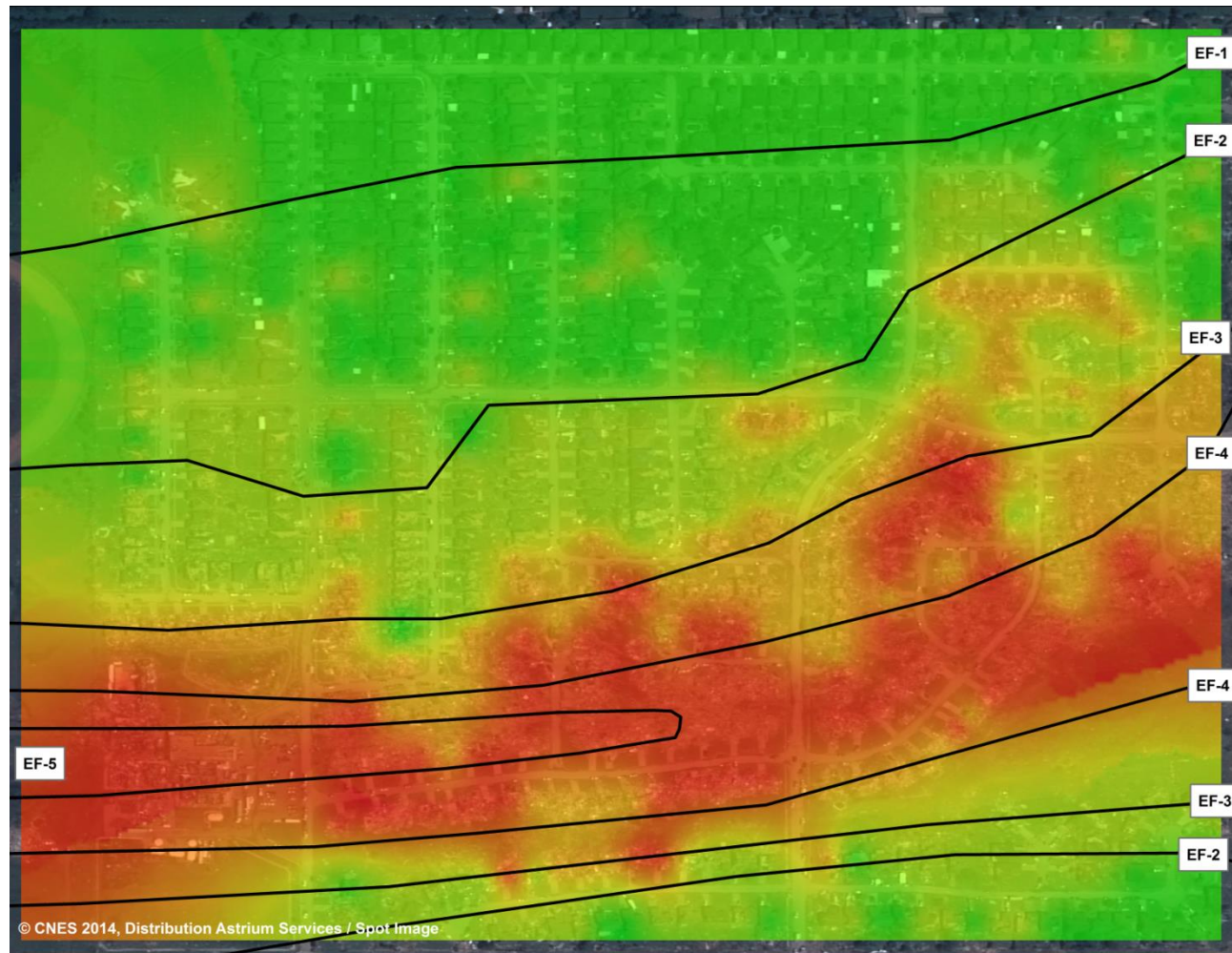
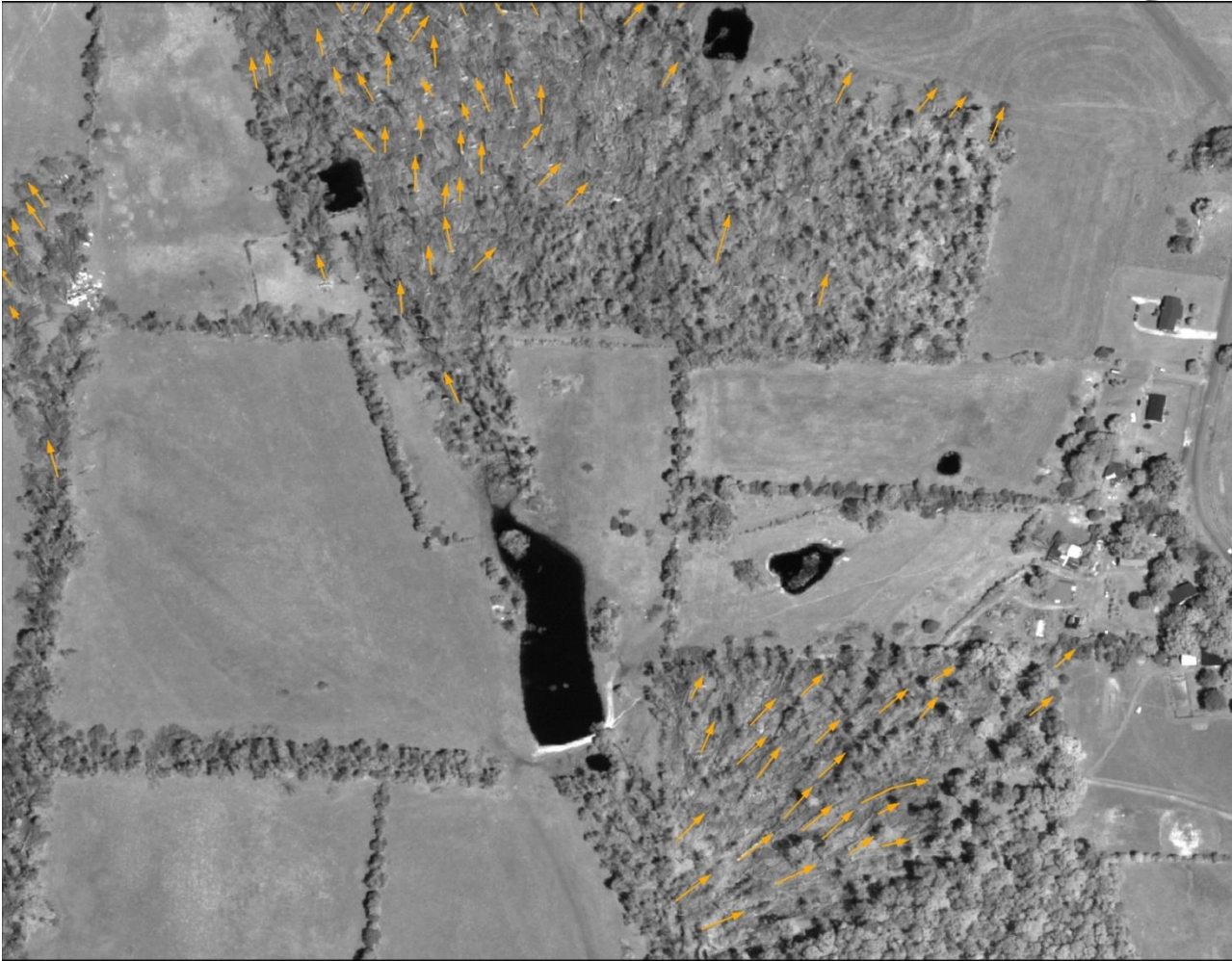*'Subjective structural analysis' technique interpolated using ArcGIS with official NWS Survey overlaid on top.*

Washington, IL—17 Nov. 2013

© COPYRIGHT 2013 DigitalGlobe, Inc.

Debris made it possible for track to be followed in fields. Could have aided in getting preliminary data out there.

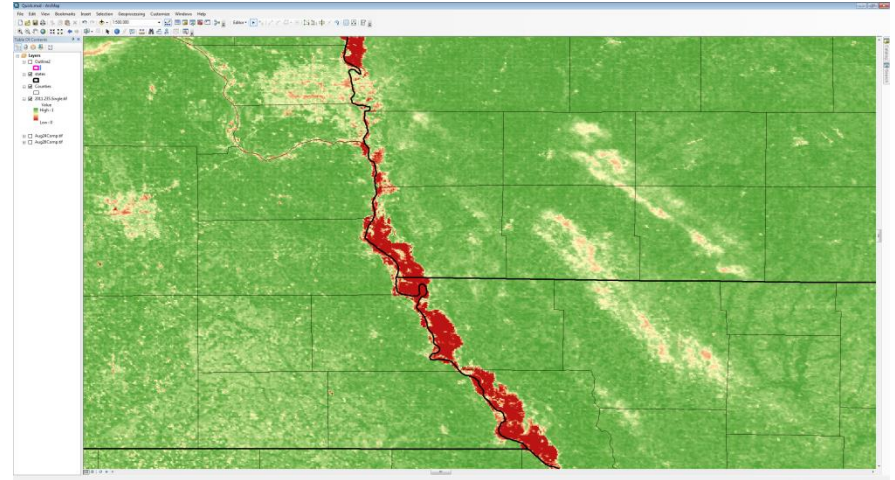*Imagery acquired from Worldview 1 on November 18, 2013. Resolution ~0.5m.*

Lincoln Co., TN—28 April 2014

- *Imagery acquired from Worldview 1 on 4 May 2014. Resolution ~0.5m. Orange arrows indicate tree fall.*

- *NWS Huntsville inquired about imagery to help with damage surveys, specifically in one area.*

- *Tree fall detection can help NWS Surveys in remote areas, especially when other data (i.e. radar signatures) are suggesting different outcome*

- *Continued development of detection algorithms will lead to automation of a similar tree fall product*

Hail Detection Algorithm

- As with tornado track detection, hail causes significant damage to vegetation

- Damage can be identified as changes in vegetation index (e.g. NDVI) and land surface temperature, but manual analysis is too time consuming

- Develop algorithm to identify damage areas
  - Currently focused on using NDVI & LST to develop algorithm from case study analysis

An example of short-term NDVI change with hail streaks evident in Iowa and Missouri, with possible manual analysis via GIS and hand-drawn shapefiles.
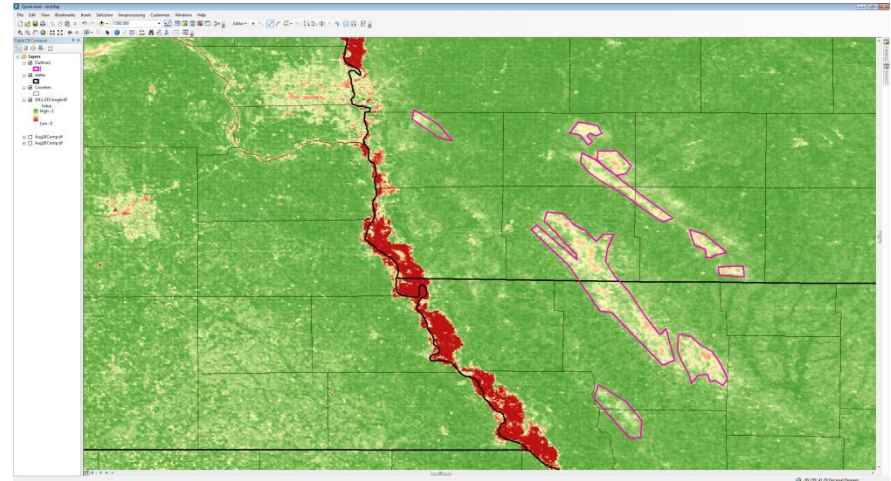
Hail Detection Algorithm

- As with tornado track detection, hail causes significant damage to vegetation

- Damage can be identified as changes in vegetation index (e.g. NDVI) and land surface temperature, but manual analysis is too time consuming

- Develop algorithm to identify damage areas
  - Currently focused on using NDVI & LST to develop algorithm from case study analysis

An example of short-term NDVI change with hail streaks evident in Iowa and Missouri, with possible manual analysis via GIS and hand-drawn shapefiles.
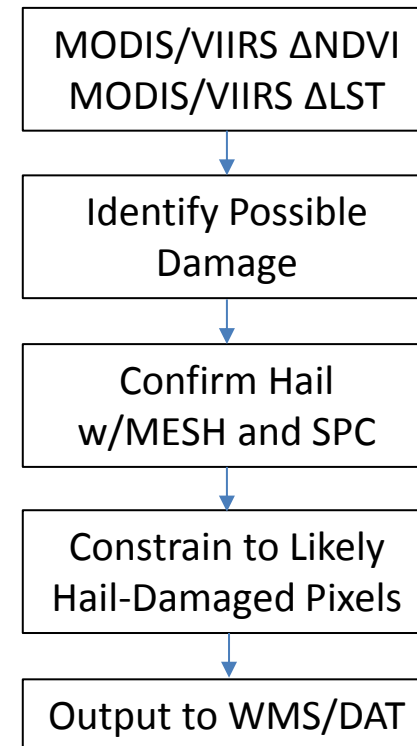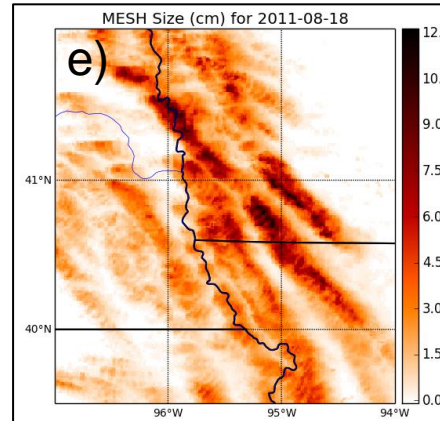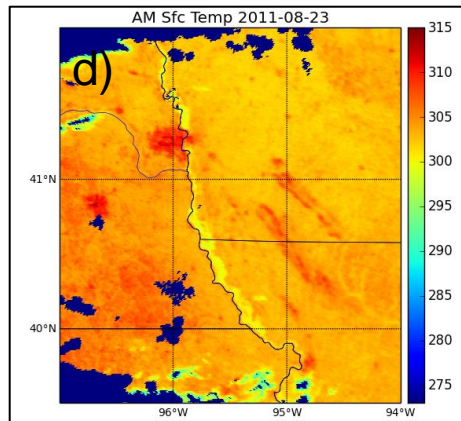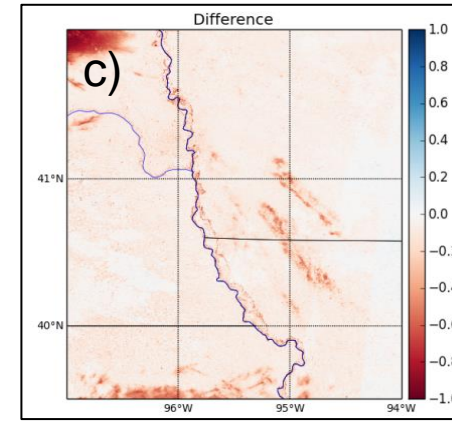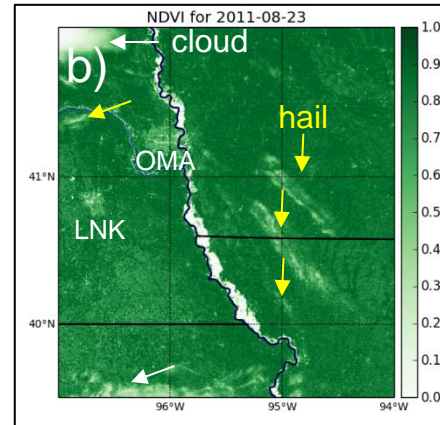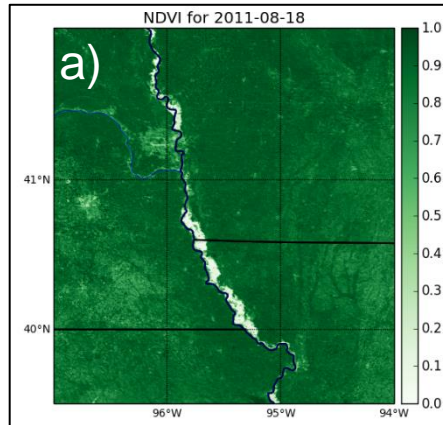
Hail Detection Algorithm

- As with tornado track detection, hail causes significant damage to vegetation

- Damage can be identified as changes in vegetation index (e.g. NDVI) and land surface temperature, but manual analysis is too time consuming

- Develop algorithm to identify damage areas
  - Currently focused on using NDVI & LST to develop algorithm from case study analysis

MODIS/VIIRS ΔNDVI
MODIS/VIIRS ΔLST

↓

Identify Possible Damage

↓

Confirm Hail w/MESH and SPC

↓

Constrain to Likely Hail-Damaged Pixels

↓

Output to WMS/DAT

Conceptual algorithm envisioned for the identification of hail-damage pixels using near real-time MODIS imagery.

Case Study: August 18, 2011

*Examples of case study imagery, various data sets, and signals for incorporation into a hail damage detection algorithm. (a) Pre-event NDVI imagery, (b) Post-event NDVI imagery, with scars identifiable, (c) Short-term change in NDVI resulting from hail damage, (d) Scars evident in relatively warmer land surface temperatures, and (e) Confirmation of hail fall through radar-derived MESH product.*

Hail Detection Algorithm

- Longer-term goal is to establish a viable algorithm to aid in damage detection, for inclusion in the DAT.

- NWS meteorologists do not routinely perform hail damage surveys, some offices do keep detailed

- Additional info can be provided to
  - End users (NWS, USDA, USGS)
  - Emergency managers
  - Interested parties to aid in damage assessments.
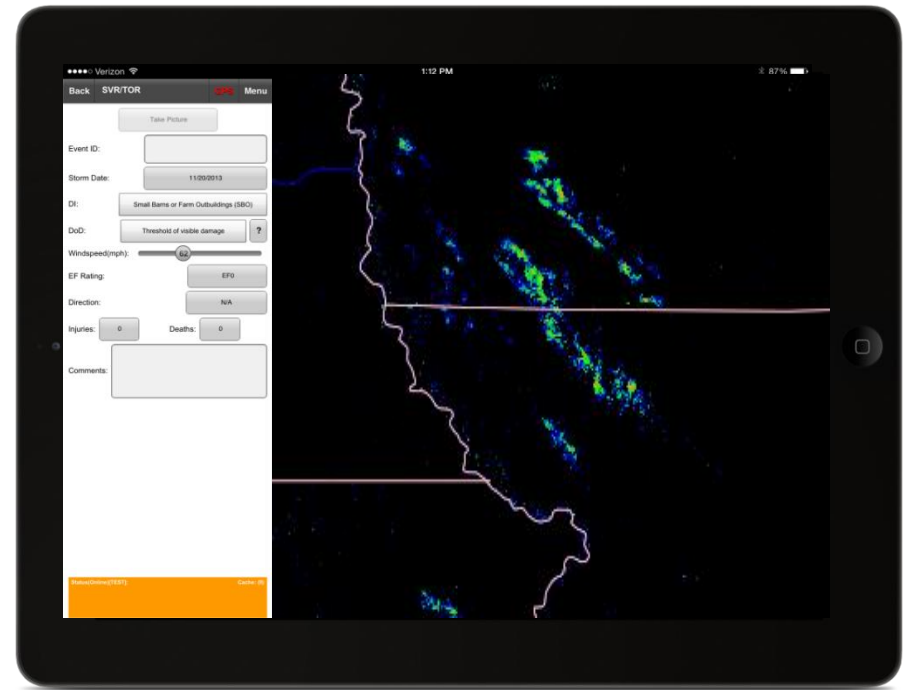
When completed, the hail detection algorithm can be incorporated as an additional near real-time product for inclusion in the DAT, supplementing radar-based products that identify hail fall regions.

Summary & Future Work

- Previous SPoRT work has lead to the development of techniques and products using NASA satellites to detect damage as a result of severe storms.
  - Work will continue to improve the skill of these techniques, while incorporating new NASA satellites
- Using high resolution commercial data can provide an additional vantage point for survey teams, especially in rural and remote areas.
  - SPoRT will continue to work developing damage detection methodologies (texture, tree falls) to supplement surveys
- Automatic hail damage detection algorithm will help SPoRT expand into converting all methodologies and techniques to performing automatically.
  - Automatic algorithms will help to incorporate other datasets and SPoRT expanding beyond just severe weather impacts