Using Satellite Imagery to Identify Tornado Damage Tracks and Recovery from the April 27, 2011 Severe Weather Outbreak

Tony A. Cole[1,3], Andrew L. Molthan[2], Jason E. Burks[2], and Jordan R. Bell[3]

[1] NASA Summer Intern Program / University of Southern Maine, Portland, Maine

[2] NASA/Marshall Space Flight Center, Huntsville, Alabama

[3]University of Alabama in Huntsville, Huntsville, Alabama

Introduction

- 25-28 April 2011: The largest single-month tornado outbreak in the history of the United States occurred across fifteen states.
  - 358 – observed tornadoes
  - 337 – lives lost during the outbreak
  - 11 – billions of dollars in total damage
- Moderate and high resolution satellite imagery can support National Weather Service (NWS) surveys by providing a high-level view of the affected areas (Yuan et al. 2001, Jedlovec et al. 2006, Myint et al. 2008) (Fig. 1).
- Meteorologists from NWS Weather Forecasting Offices (WFOs) in Huntsville and Birmingham, AL surveyed damage to map tornado tracks, assess damage and determine tornado intensity following each event (Fig. 2).
- In this study, the feasibility of using satellite imagery to identify tornado damage tracks was determined by comparing the characteristics of tracks observed from space to tracks assessed during the official NWS storm survey process.

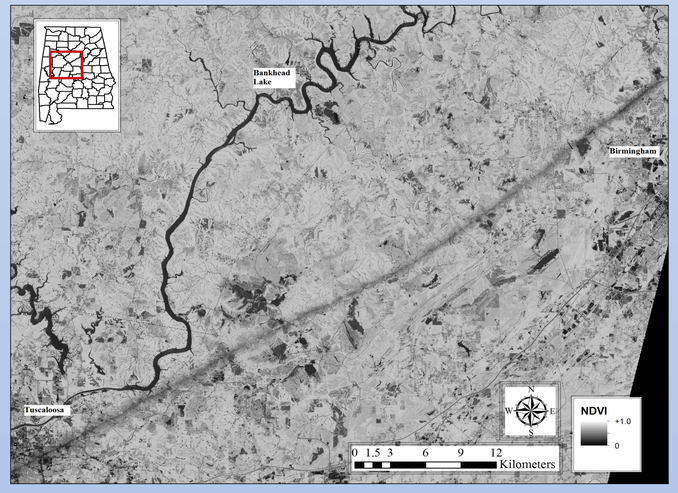

Figure 1. Tuscaloosa-Birmingham tornado damage track evident in ASTER NDVI imagery from 4 May 2011.

Methods

- Used MODIS and ASTER satellite imagery to calculate a Normalized Difference Vegetation Index (NDVI)

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

- Digitized tornado damage tracks present in NDVI products using ArcGIS for Desktop's editor tool (Fig. 3)
- Compared identifiable damage tracks to those surveyed by NWS survey crews (Fig. 4)
- Compared characteristics of satellite-derived tracks to NWS field survey swaths and centerlines (Fig. 5-7)
- Used Landsat-7 to assess recovery in urban and rural areas of Tuscaloosa, AL for post-event years using a Normalized Difference Build-Up Index (NDBI) (Fig. 8)

$$NDBI = \frac{(R_{MIR} - R_{NIR})}{(R_{MIR} + R_{NIR})}$$

Tornado Damage Track Identification

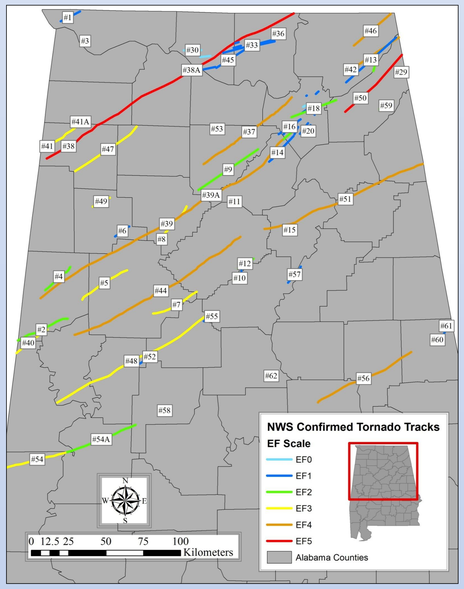

Figure 2. Distribution of NWS field surveys across Alabama.

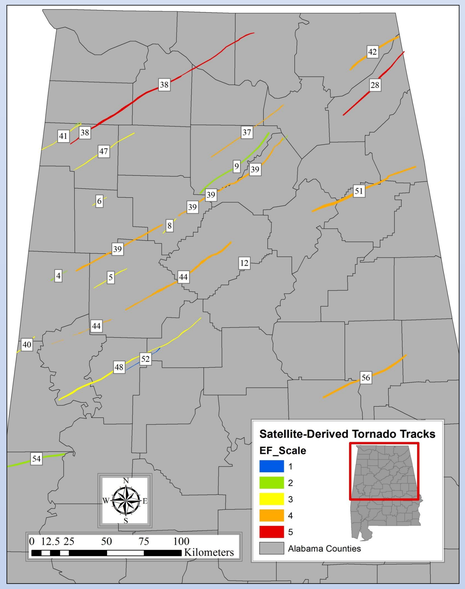

Figure 3. Distribution of tornado damage tracks evident in MODIS and ASTER imagery.

Comparison of Tornado Track Characteristics

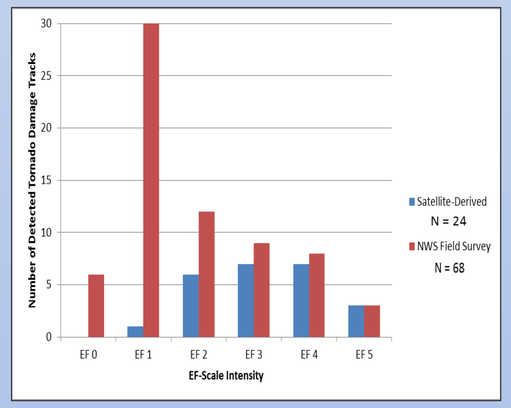

Figure 4. Distribution along the EF-scale of identified tornado damage tracks by detection technique.

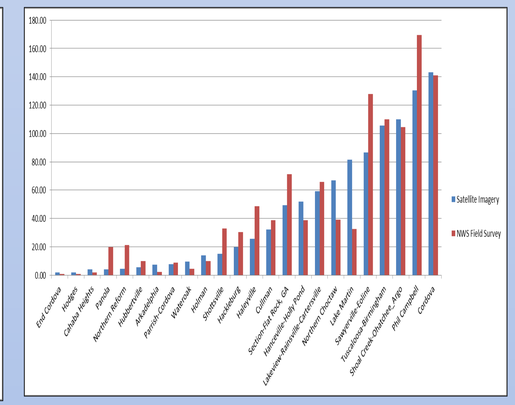

Figure 5. A comparison of tornado damage track areas as observed from satellite imagery versus NWS field surveys.

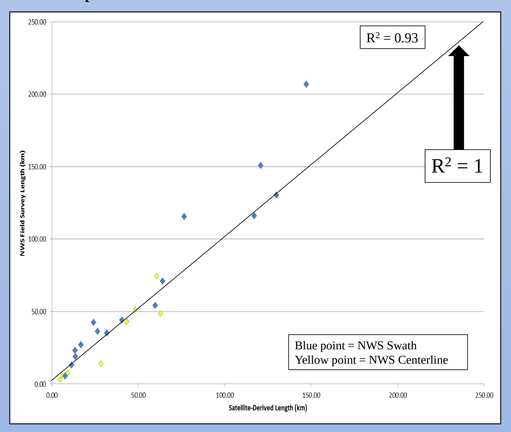

Figure 6. A comparison of tornado damage track total lengths as observed from satellite imagery versus NWS field surveys.

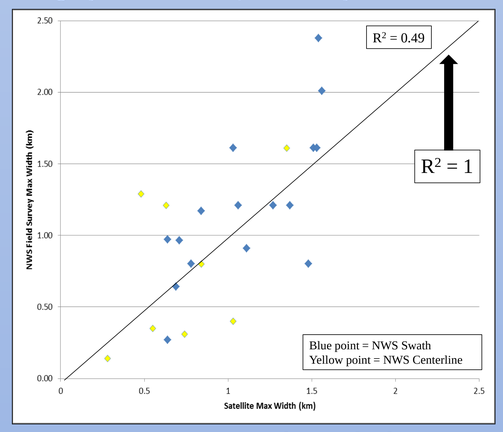

Figure 7. A comparison of tornado damage track maximum widths as observed from satellite imagery versus NWS field surveys.

Assessing Recovery in Tuscaloosa, AL

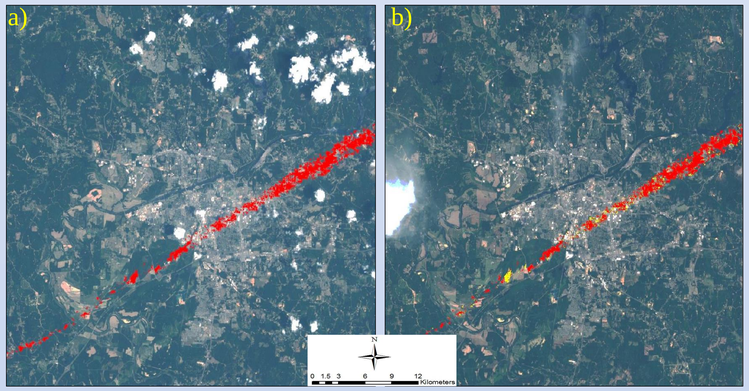

Figure 8. Determination of damaged and recovered areas in Tuscaloosa, Alabama based upon the use of the NDBI as derived from Landsat-7 imagery. a) Recovery image for 2012, where red pixels identify points still identified as damaged by comparison to pre-tornado imagery. b) Recovery image as of 2013. Yellow pixels identify areas recovered between 2012 and 2013. Red pixels identify areas which have yet to recover.

Conclusions

- The tornado outbreak of 27 April 2011 led to significant urban and rural damage in eastern Mississippi and throughout Alabama.
- Satellite data can be used to identify tornado damage tracks, though the minimum EF-category which can be detected is dependent upon the type of sensor used and underlying vegetation.
- Damage tracks can be identified using NDVI which shows a distinct drop in values that corresponds to higher damage, especially in well-vegetated areas.
- This study achieved the following objectives:
  - determined that satellite imagery can be used to visually identify tornado damage tracks,
  - compared key characteristics of satellite-derived tracks to those observed during field surveys,
  - compared changes in NDVI using MODIS and ASTER imagery,
  - and monitored recovery following the 27 April 2011 event.

References

Jedlovec, G. J., U. Nair, and S. L. Haines, 2006: Detection of Storm Damage Tracks with EOS Data. *Wea. Forecasting*, **21**, 249-267.

Myint, S.W., M. Yuan, R.S. Cerveny, and C.P. Giri, 2008: Comparison of Remote Sensing Image Processing Techniques to Identify Tornado Damage Areas from Landsat TM Data. *Sensors*, **8**, 2, 1128-1156.

Wagner, M.A., S.W. Myint, R.S. Cerveny, 2012: Geospatial Assessment of Recovery Rates Following a Tornado Disaster. *Geoscience and Remote Sensing*, **50**, 4313-4322.

Yuan, M., M. Dickens-Micozzi, M. A. Magsig, 2001: Analysis of Tornado Damage Tracks from the 3 May Tornado Outbreak Using Multispectral Satellite Imagery, *Wea. Forecasting*, **17**, 382-398.

Acknowledgments

Author gives special thanks to mentors Andrew Molthan, Jason Burks and Gary Jedlovec; internship coordinators Tina Atchley and Mona Miller; Jordan Bell and Rachel Dryden.