Use of NASA Satellite Data in Tornado Damage Path Assessment

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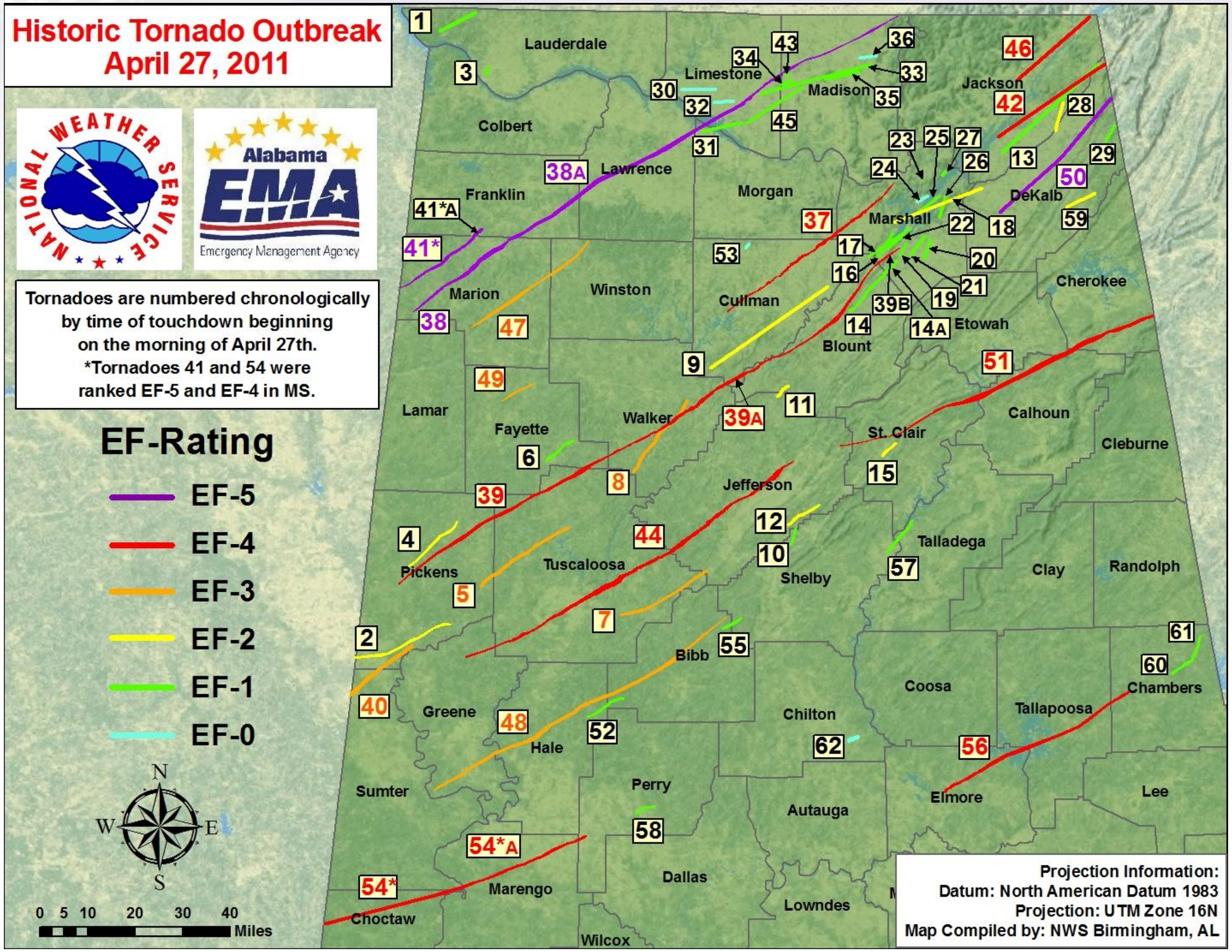
27 April 2011 Outbreak

- 62 tornadoes in Alabama in 18 hours
  - 3 EF-5s, 8 EF-4s, 8 EF-3s
- 3 distinct waves (early morning, midday, afternoon)
- 40 tornado paths (6 violent) in Huntsville CWA alone



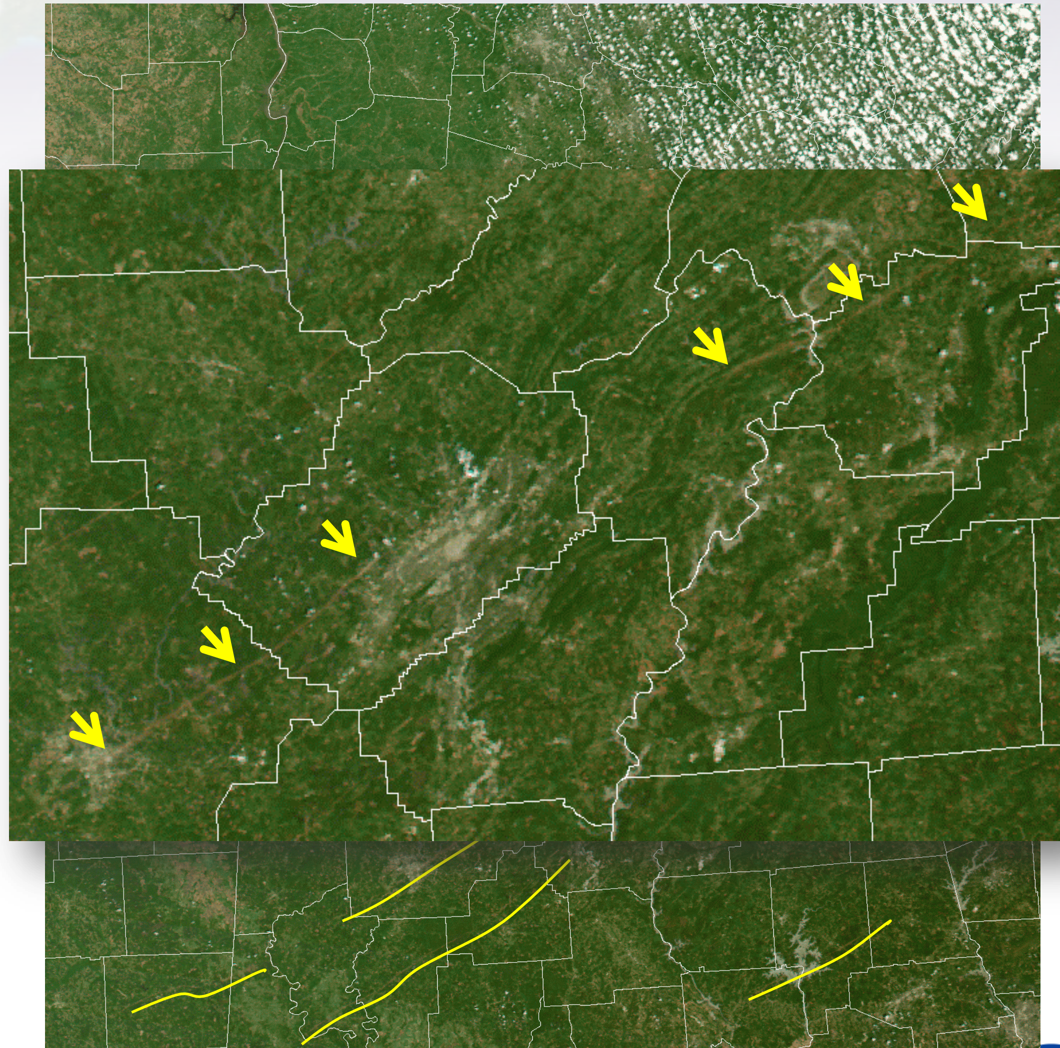
The Challenge

- Surveying this amount of damage alone is difficult; adding the desired level of detail creates additional challenges
  - Smartphone-based surveying toolkit (in beta testing) helps with the detail issue, but still requires time, staffing, and access
- Multiple paths and multiple events (15 & 27 April) need a "big picture" perspective to help integrate & supplement ground surveys
  - Aerial surveys are very useful for gaining a larger understanding of individual tracks, but they tend to be focused on a single track and may not provide larger context

MODIS

(Moderate Resolution Imaging Spectroradiometer)

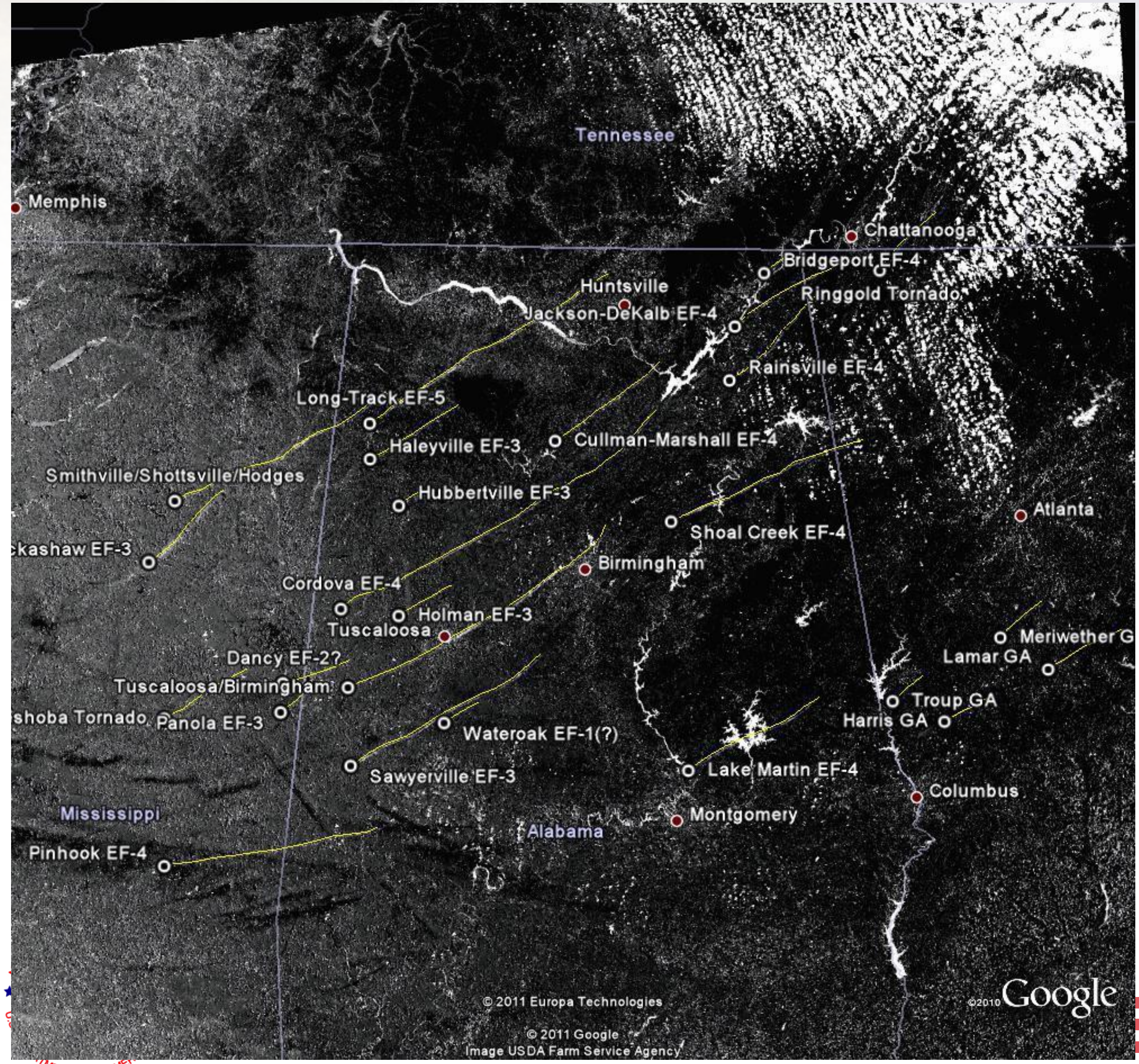
- Routinely provided by SPoRT in AWIPS at a peak resolution of 250m
- Increased channels allow for production of color composites (including “natural color”)
- Destruction of vegetation modifies surface reflectance
- Natural color easy to interpret & communicate, but tougher to make out paths



SPoRT Collaboration

- SPoRT and much of north Alabama were affected by a large power outage for almost a week after the outbreak
- Once SPoRT resumed operations, WFOs BMX and HUN worked with SPoRT to acquire imagery in KML format
  - Superior to AWIPS for survey-related purposes (measurements, zooming, layers, etc.)
- SPoRT responded with channel-differenced before-and-after MODIS imagery
  - Subtract post-event image from pre-event image to make damage swaths stand out
- SPoRT also worked to acquire data from ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer), which has a peak resolution of 15m

250m MODIS Difference Image



- Difference in Channel 1 (red, most susceptible to changes in vegetation) between 4 May & 22 April
- Identified 26 tornado paths in most of MS and AL, and parts of GA and TN
  - Included all but 1 significant (EF-3+) tornado
  - Included an EF-1 and 2 EF-2 tornadoes
  - More than half of the paths have a length within 5 miles of the surveyed length
- 250m resolution limited detection of other tracks

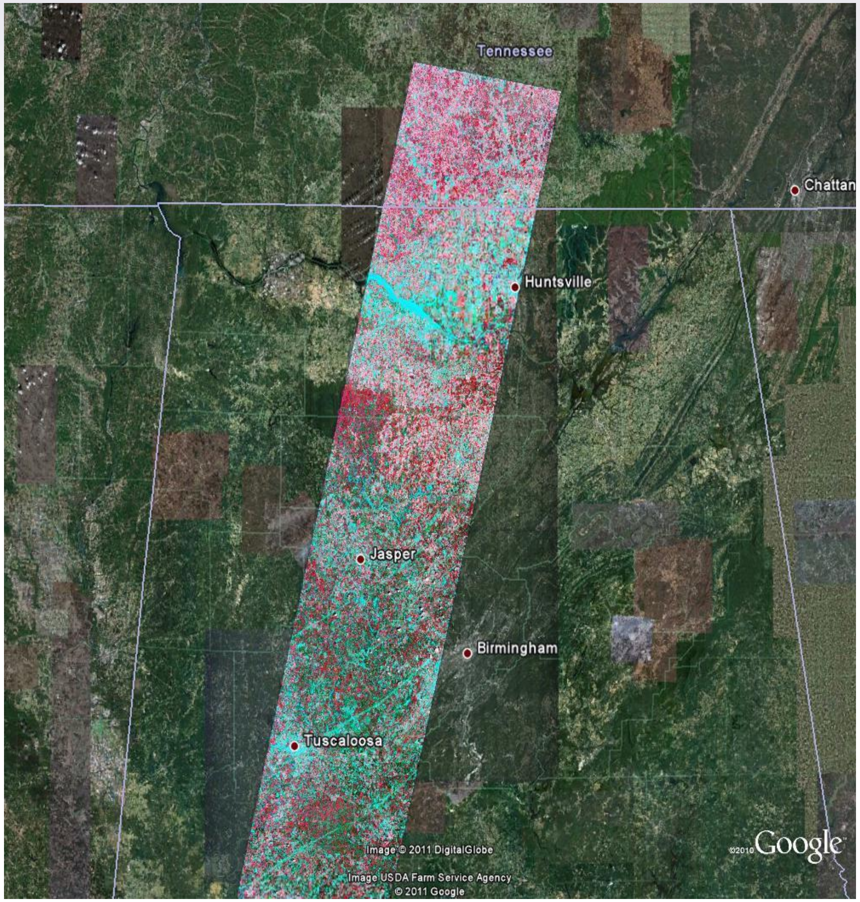
MODIS Testimonials

- "MODIS imagery helped us in adjusting a tornado track which tracked from northeastern Alabama into extreme northwestern Georgia [Rainsville EF-5]. We were aware that the path took a left turn, but we weren't certain how much of a turn it was. It helped us get a better big-picture view, and link up our survey with one performed by our colleagues in the Peachtree City, Georgia office to confirm one, consistent track."
  --David Nadler, HUN WCM

- "We used the data to confirm that the Tuscaloosa tornado start point was in Greene County, as we suspected. This was initially confusing because we had leftover damage from the April 15th event that could have been easily attributed to April 27th. The April 15th paths did not show up on the data, at least not like the 27th."
  –Kevin Laws, BMX Lead Forecaster

ASTER Imagery

- Aboard Terra
- Data must be specially requested
- Peak resolution 15 m, but narrower swath (60 km)
- Channels also allow for RGB composites
  - Forested areas appear red, open fields & bodies of water cyan



ASTER Analysis:

Phil Campbell/Hackleburg/Tanner EF-5

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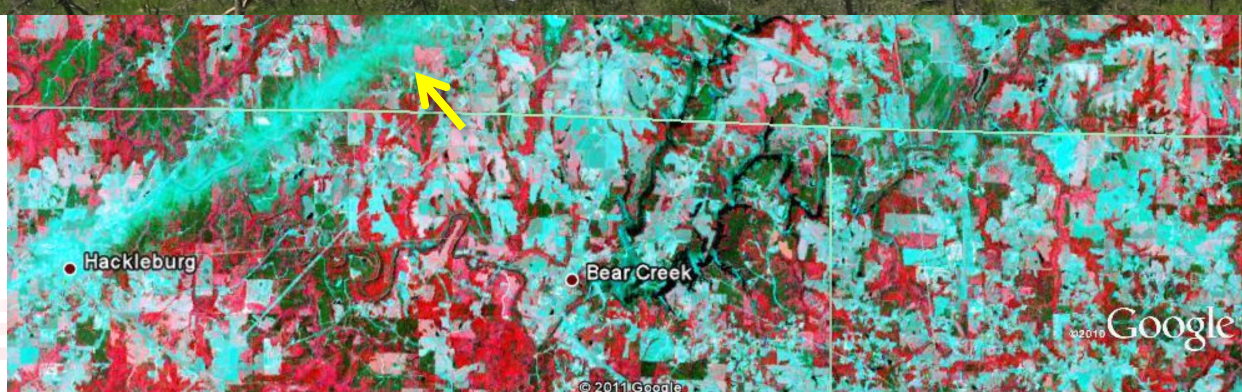
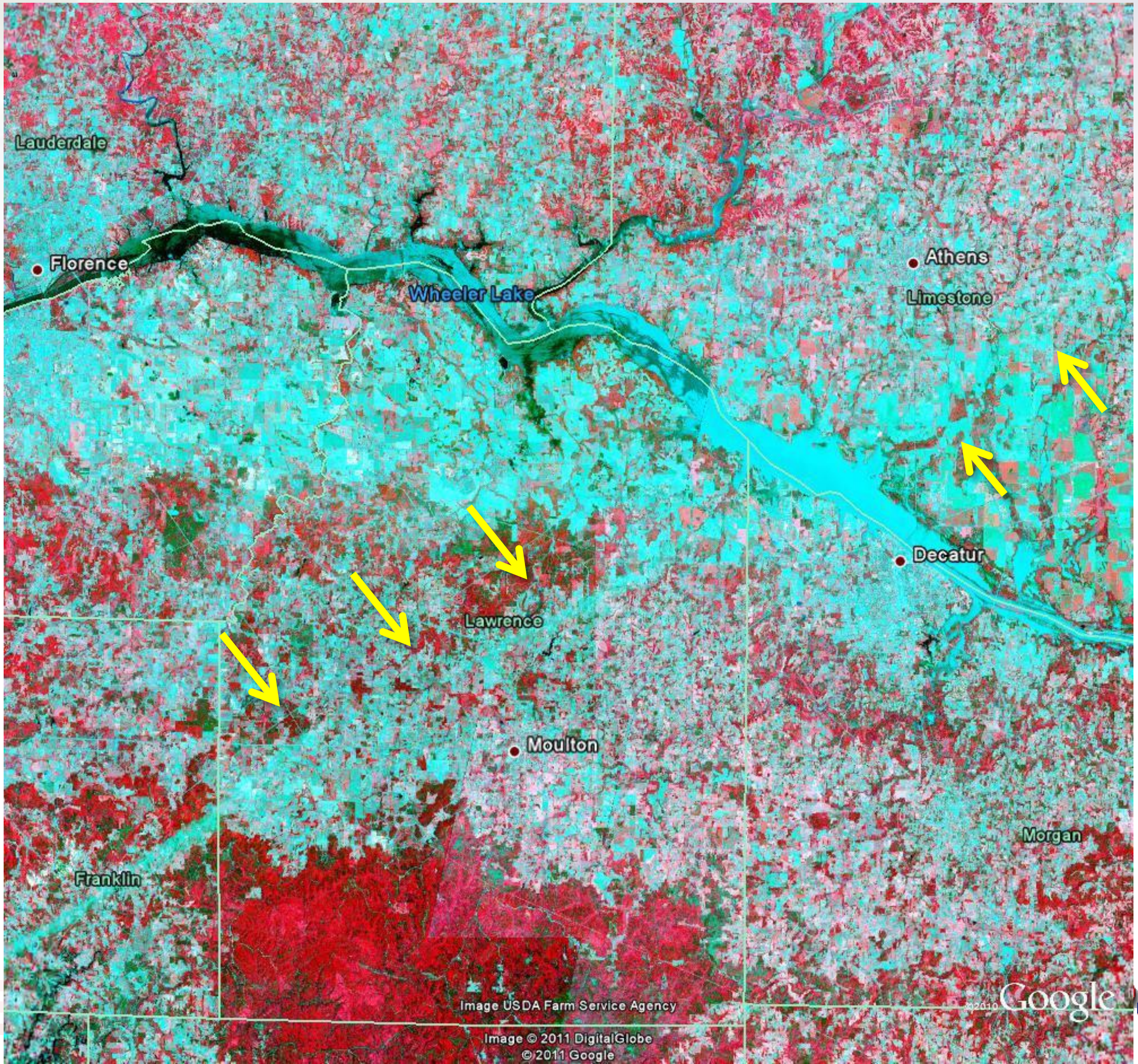
Damage "Gradient"



ASTER Analysis:

Phil Campbell/Hackleburg/Tanner EF-5

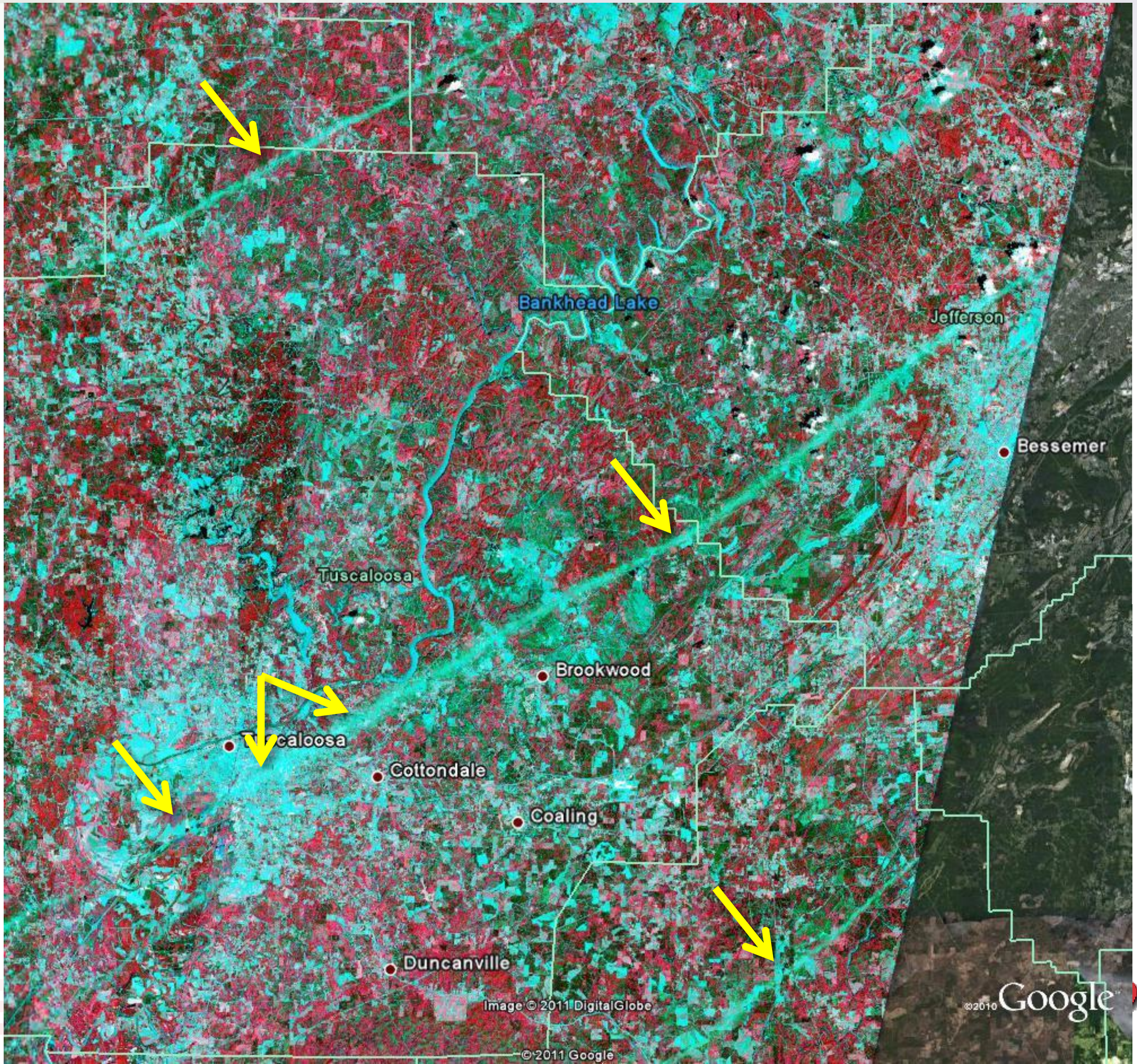
Path weakens (almost disappears) and "wobbles" in Lawrence County



Path almost disappears in open, fallow fields of Limestone County

ASTER Analysis:
Tuscaloosa-Birmingham EF-4

Three paths visible in this image



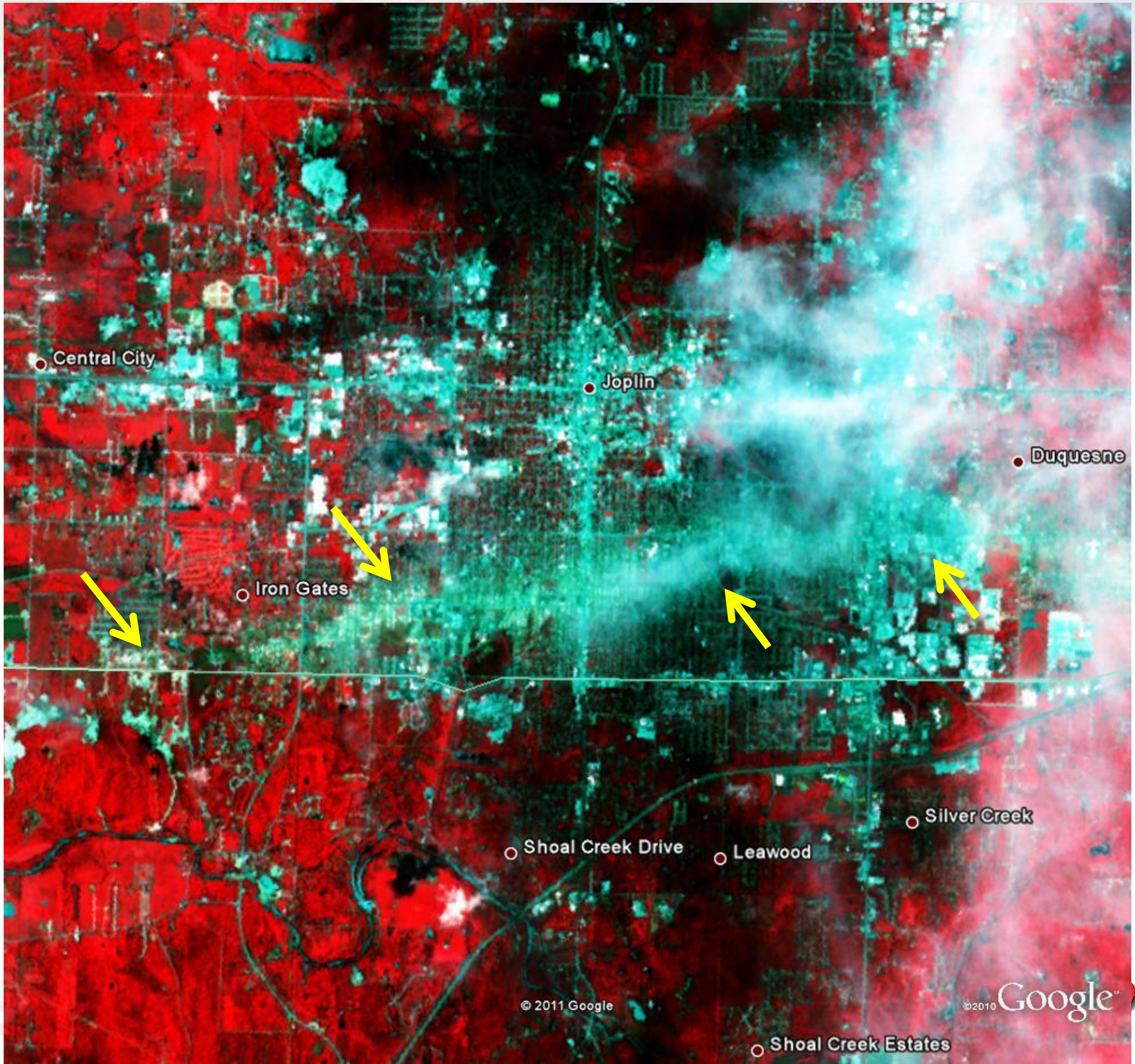
Another path "wobble" on Jefferson-Tuscaloosa county line

Path widens significantly upon impacting Tuscaloosa

ASTER Analysis:
Joplin, MO EF-5 – 22 May 2011*

*ASTER pass occurred 30 May

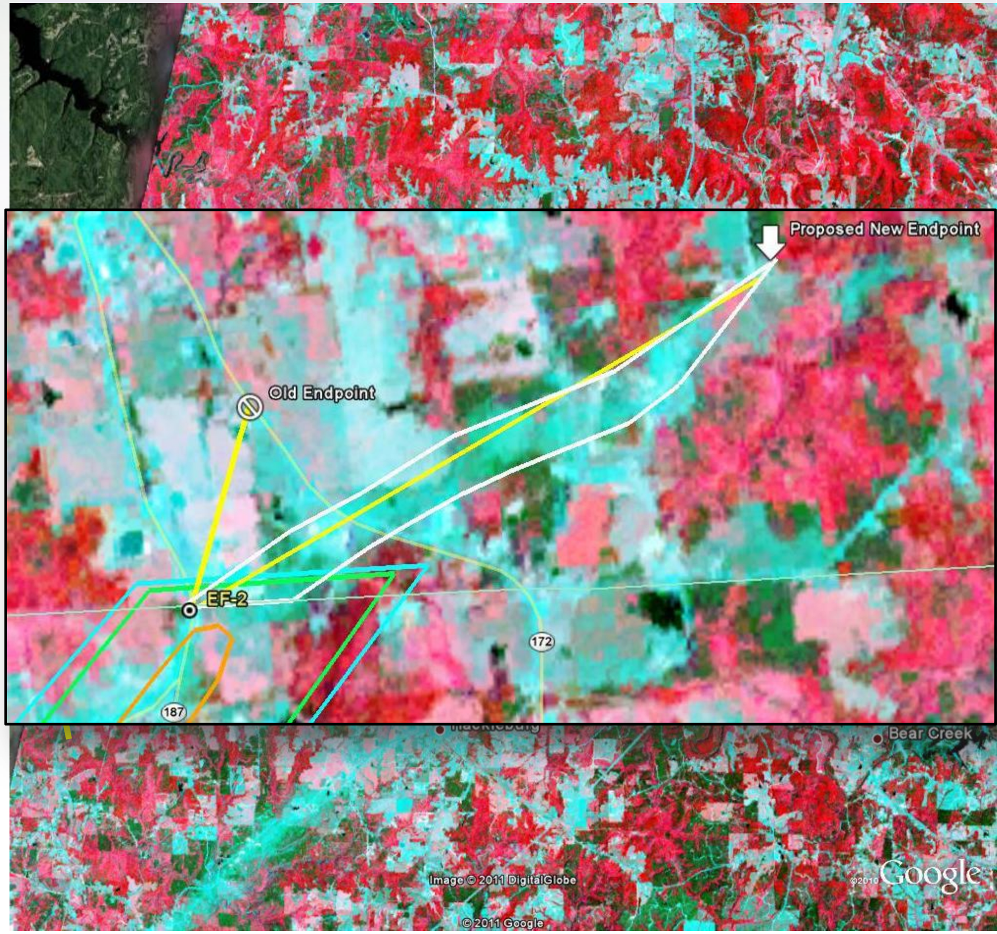
Significant increase in damage and width over ~½ mile



Path becomes increasingly difficult to detect due to cloud contamination

ASTER Testimonial

- ASTER imagery was used to help determine an end point for the Smithville, MS EF-5, which tracked into south-central Franklin County, AL (~7 miles NW of Hackleburg)
- A survey team examined most, but not all of that damage on 28 April. There was not a chance to go back, and road networks are poor in that area as it is.



Strengths & Weaknesses

Strengths

- Provide “big picture” view
  - Augments ground & aerial surveys
  - Helps target areas for ground surveys
  - Depicts variations in paths that may not be otherwise detectable
- Provide means for measuring path length and width

Weaknesses

- Not everything can be detected by satellite
  - Horizontal resolution may not capture damage paths (especially for 250m MODIS)
  - Land use may mask damage
  - Weaker tornadoes may not cause enough damage to create a reflectance change
  - Clouds can delay detection or obscure paths
- Highest-resolution imagery (ASTER) must be specially-requested

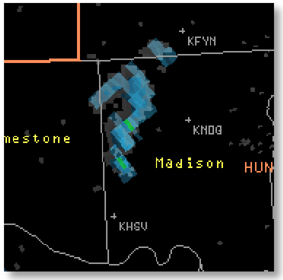
Future Efforts

- New image enhancement techniques to make storm damage stand out further
- Expediting production and release of data to WFOs for use quickly after an event

References & Links

- Jedlovec, et.al., Detection of Storm Damage Tracks with EOS Data. W&F, June 2006, 249-267.

- SPoRT Tornado Path Data (27 April): http://weather.msfc.nasa.gov/sport/tornadoes/20110427
- Joplin ASTER Data: http://weather.msfc.nasa.gov/sport/tornadoes/20110522/
- NWS Huntsville, AL Outbreak Information: http://www.srh.noaa.gov/hun/?n=hunsur_2011-04-27_main



Any questions?

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