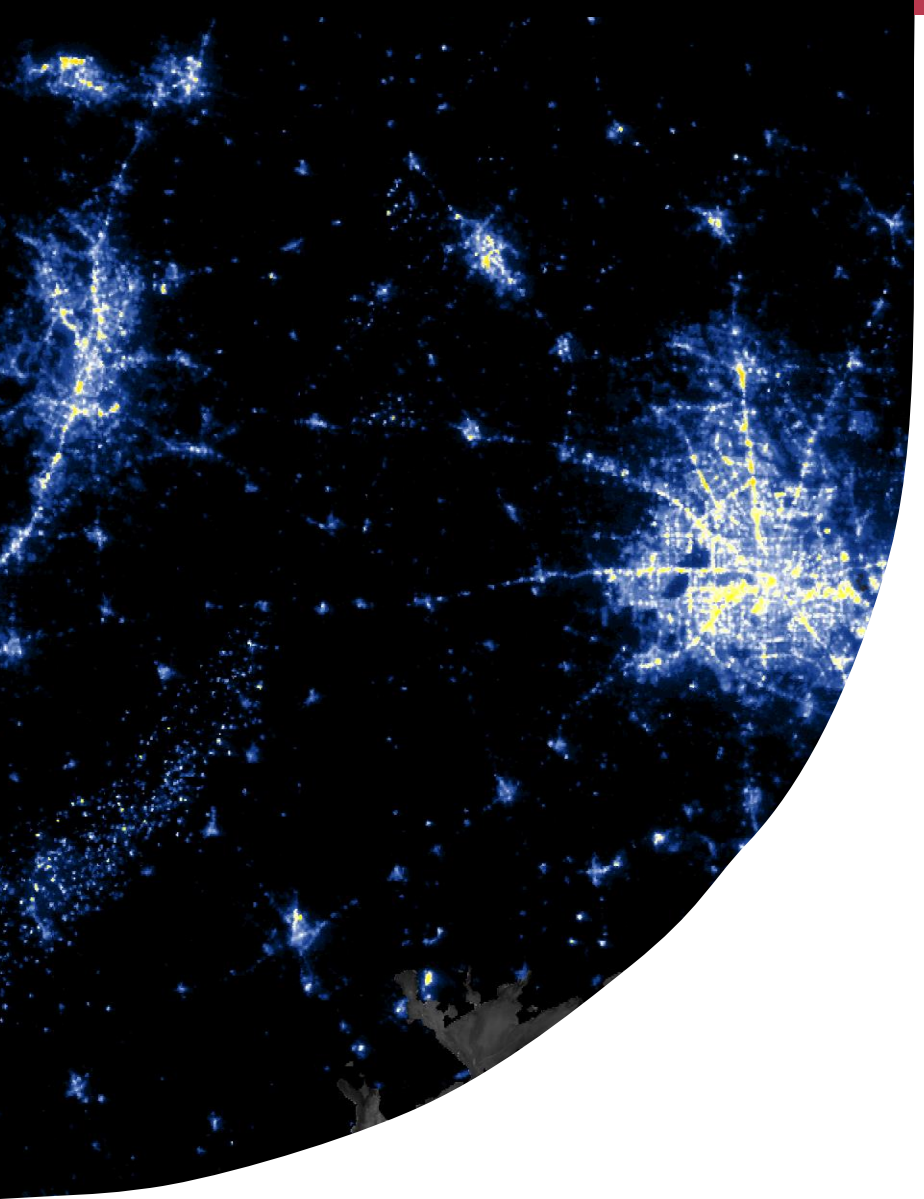
National Aeronautics and Space Administration



Kentucky & Texas Disasters

Utilizing NASA Earth Observations to Monitor the Duration and Extent of Power Outages Due to Severe Weather Events in Kentucky and Texas

Danielle Hall, Cara Hannel, Summer Coleman, Bilal Aslam(Analytical Mechanics Associates)

Pop-Up Project – Miami University | Spring 2025

Tornadoes & Derechos


Image Credit: Justin1569

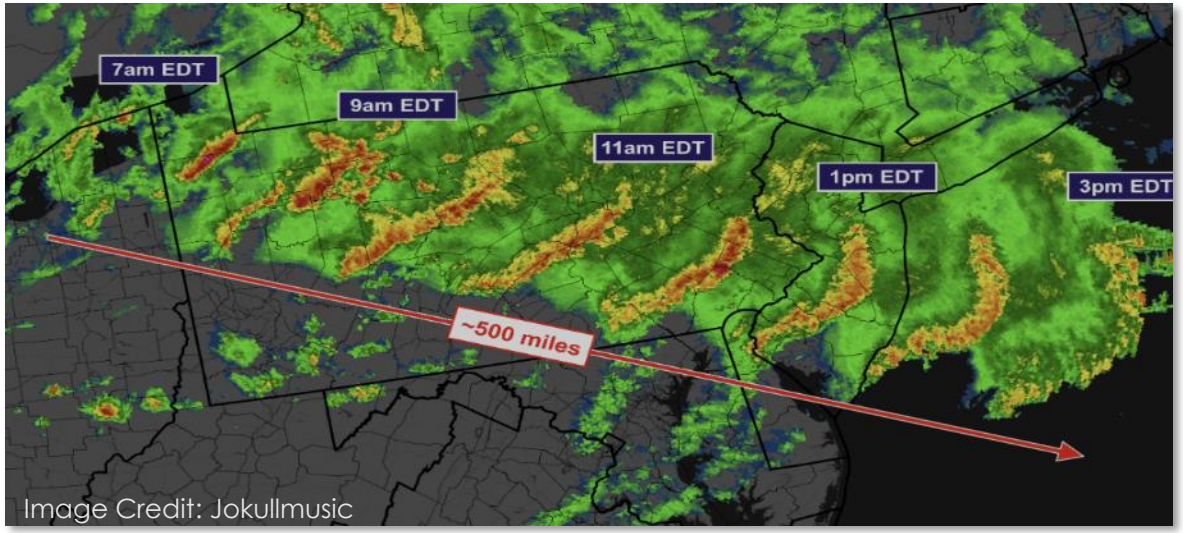


Image Credit: Jokullmusic

Tornado: Narrow, rotating column of air, smaller section of a larger storm

Produces a **narrow swath** of concentrated damage

Derecho: Family of downburst clusters which produce rapid, straight-line winds

Produces a **wider area** of less concentrated damage

Severe Weather: Community Hazards

Direct Tangible Costs


Image Credit: Ellie Burgin

Examples:

Destroyed crops, damaged electric grids, and damaged buildings

Indirect Tangible Costs


Image Credit: Harrison Keely

Examples:

Business interruption, vulnerability to carbon monoxide and temperature

Intangible Costs


Image Credit: Chris Martin

Examples:

Potential for diminished emotional security and long-term health complications

Project Partners Address Community Hazards

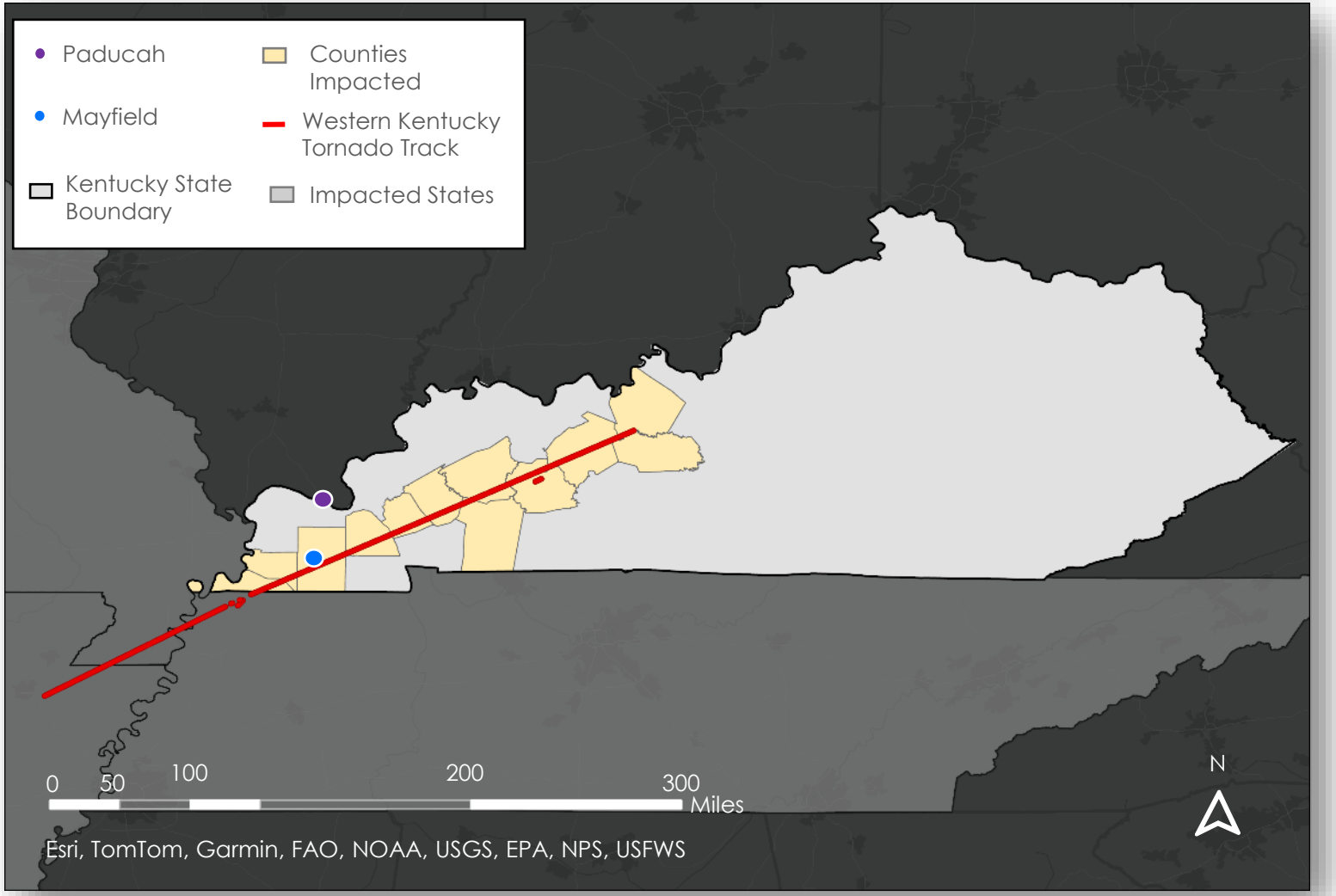
Image Credit: NOAA Great Lakes Environmental Research Laboratory and Wikipedia

National Weather Service (NWS) - Paducah, Kentucky

Image Credit: AnonMoos

Texas Division of Emergency Management (TDEM)

2021 Western Kentucky Tornado



Background

Date of Event

- December 10, 2021

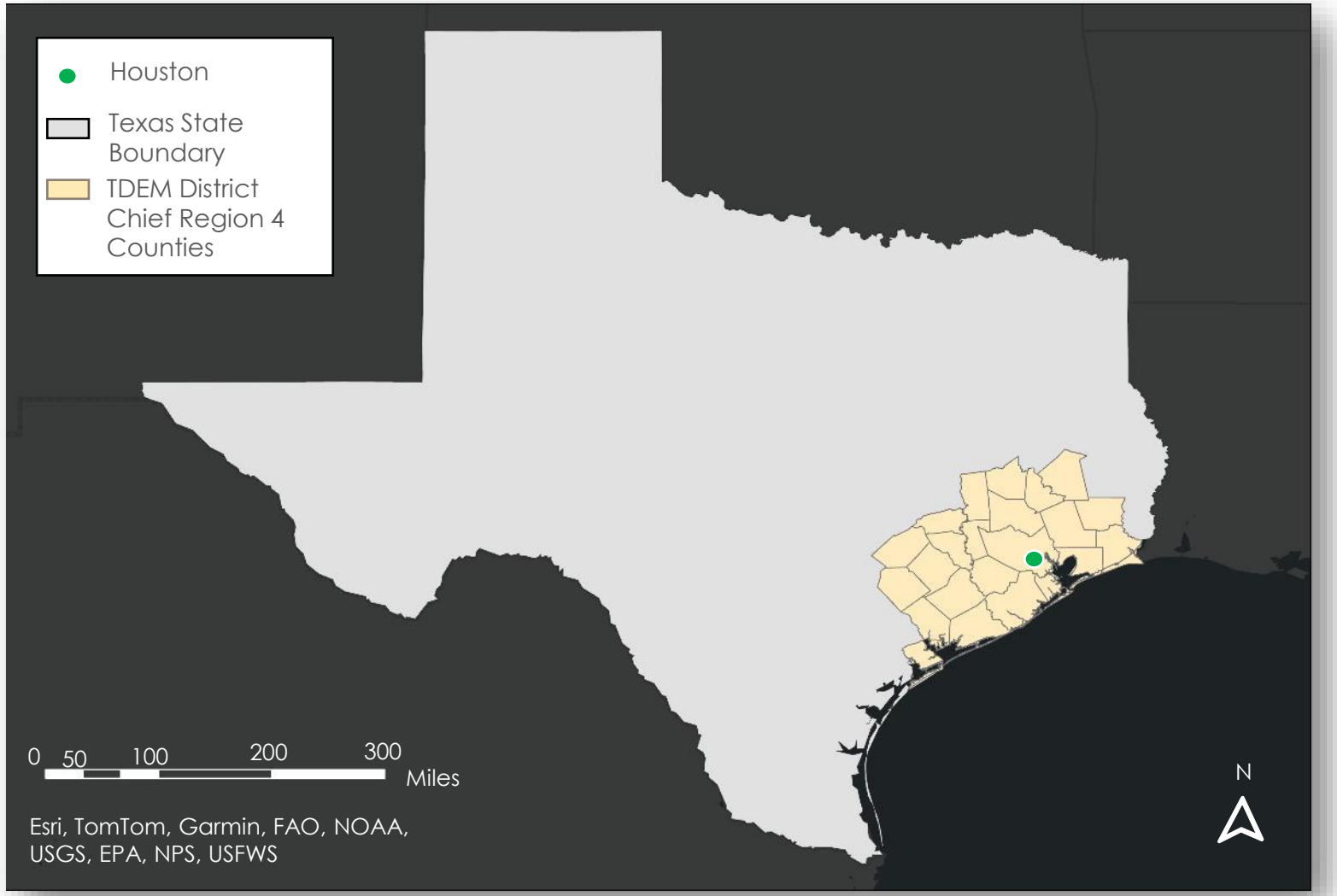
Length of track

- 165.7 miles

Intensity

- EF0-EF4
  - Potential EF5

2024 Houston Derecho



Background

Date of Event

- May 16, 2024

Length of track

- ~ 900-1000 miles
  - Central Texas through Louisiana and Florida

Intensity

- Peak recorded wind speeds of 78 mph
  - Estimates of 100 mph

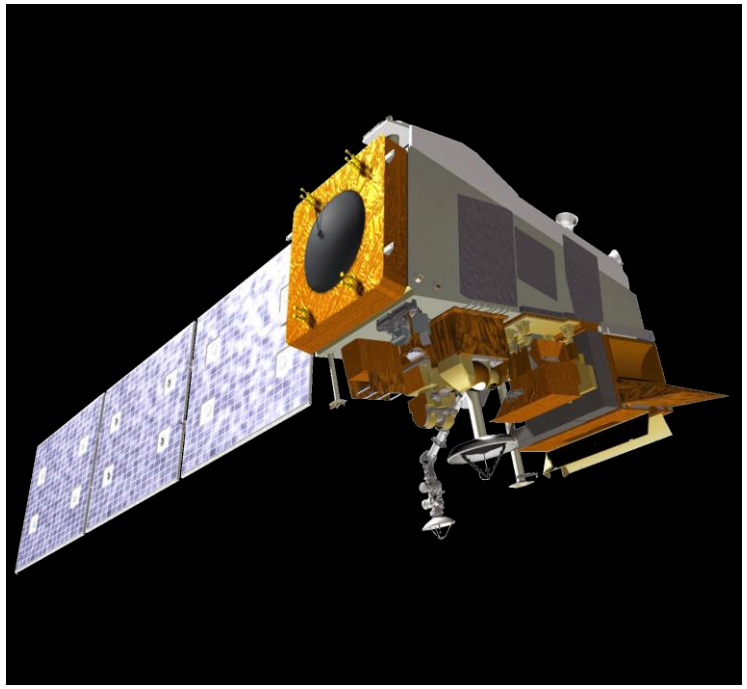

Image Credit: NASA Goddard Space Flight Center

Project Objectives

Demonstrate if Earth observations are informative for post-disaster analysis in rural and urban areas

- **Identify** damage extent through power outages
- **Identify** damage extent through vegetation damage

Earth Observations



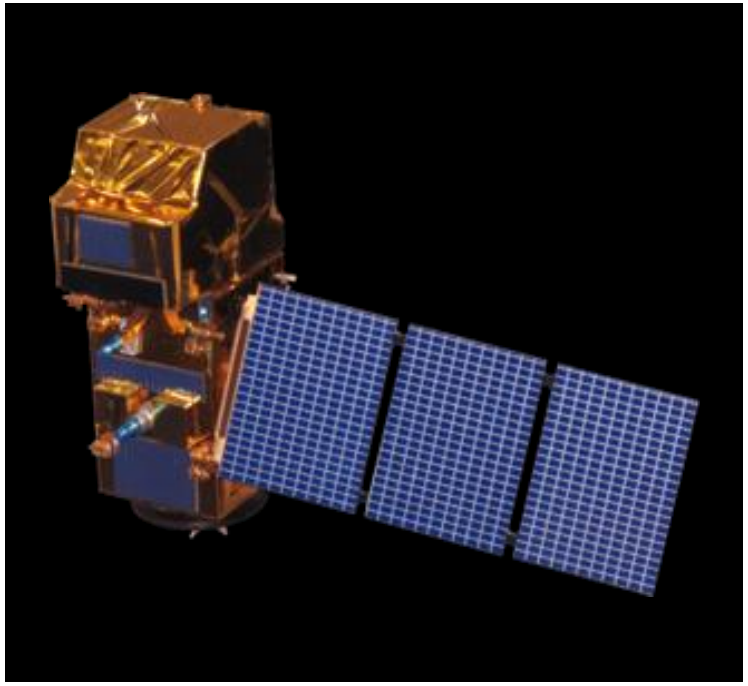


Image credits: NASA, RAMA

NOAA/NASA

Suomi NPP

Visible Infrared Radiometer Suite (VIIRS)

European Space Agency

Sentinel-2

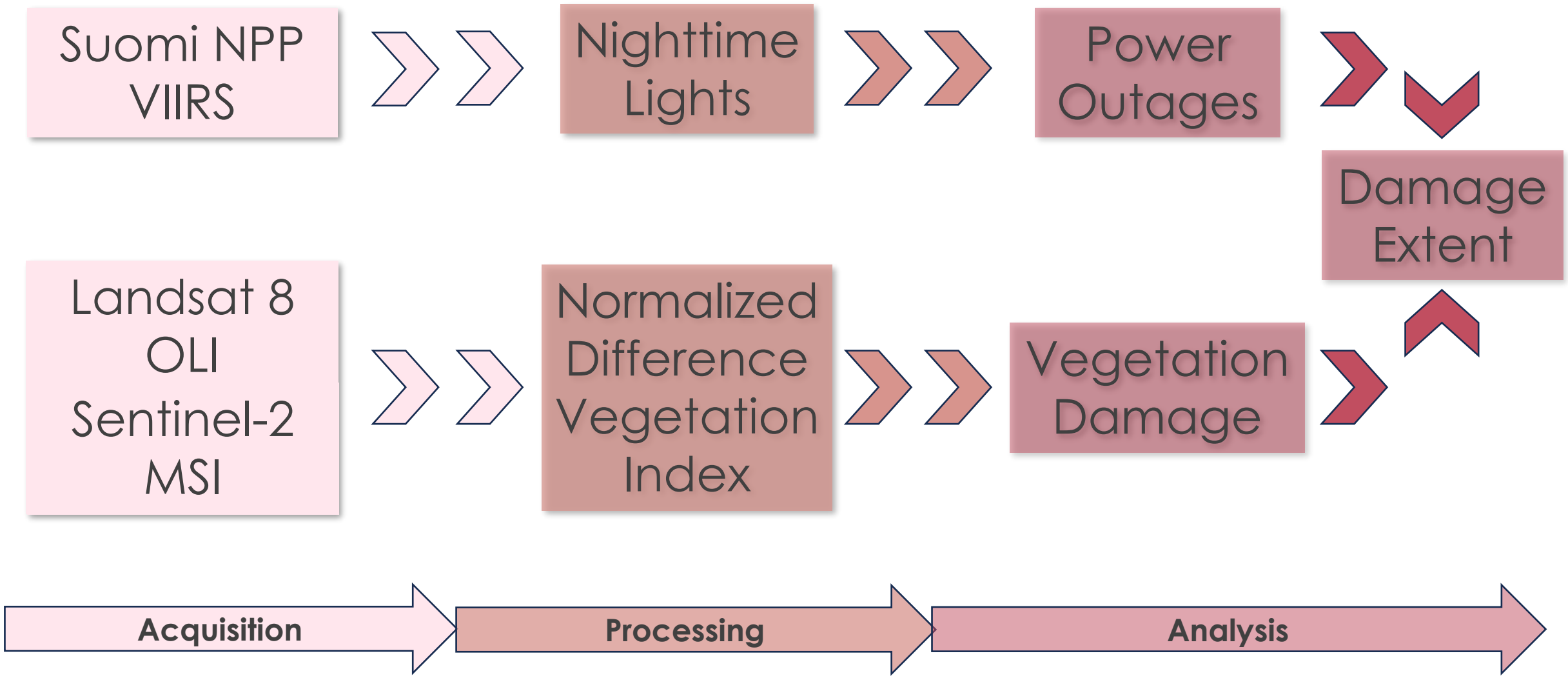
Multispectral Imager

NASA

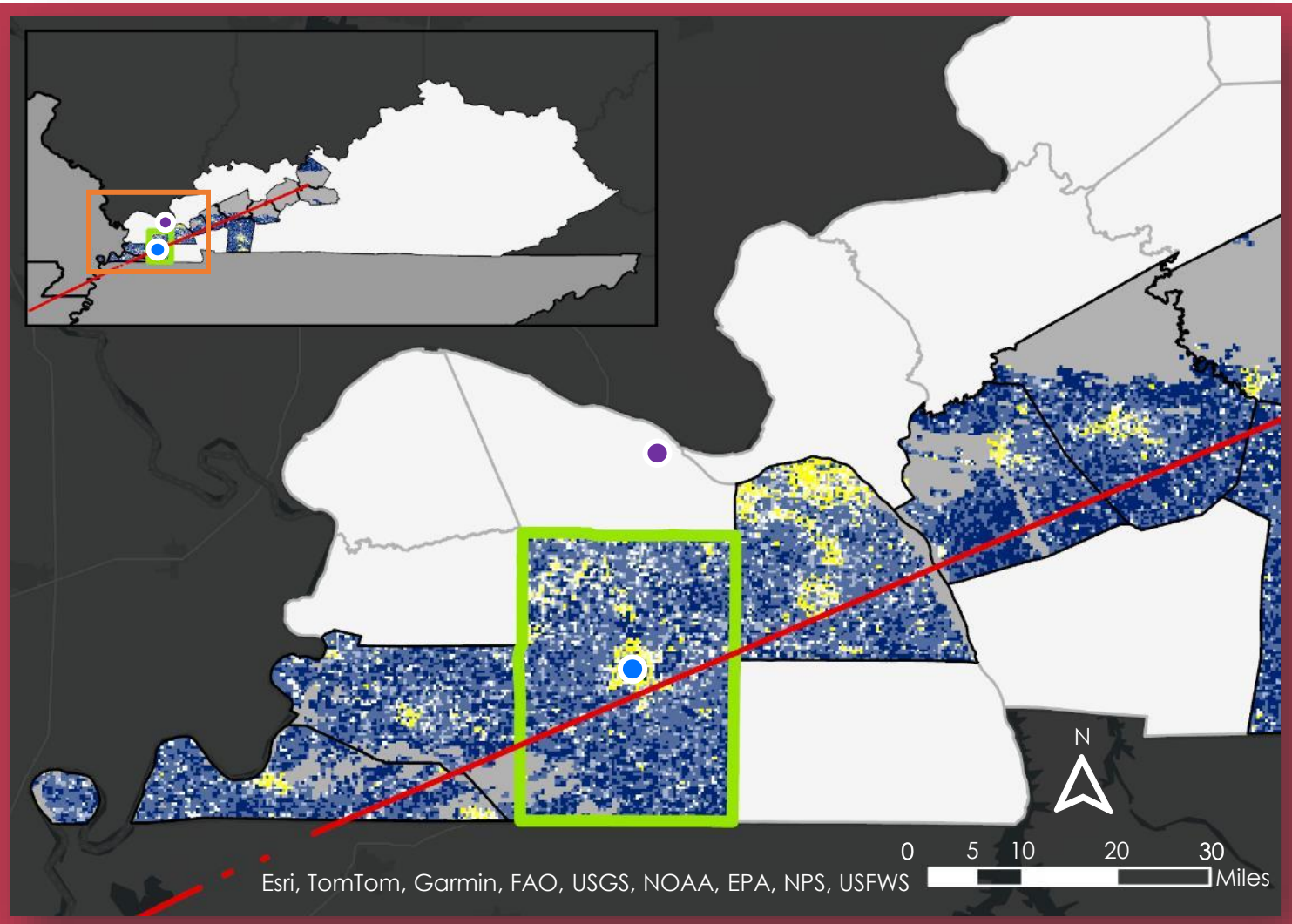
Landsat 8

Operational Land Imager

Methodology



Western Kentucky Tornado: Nighttime Lights



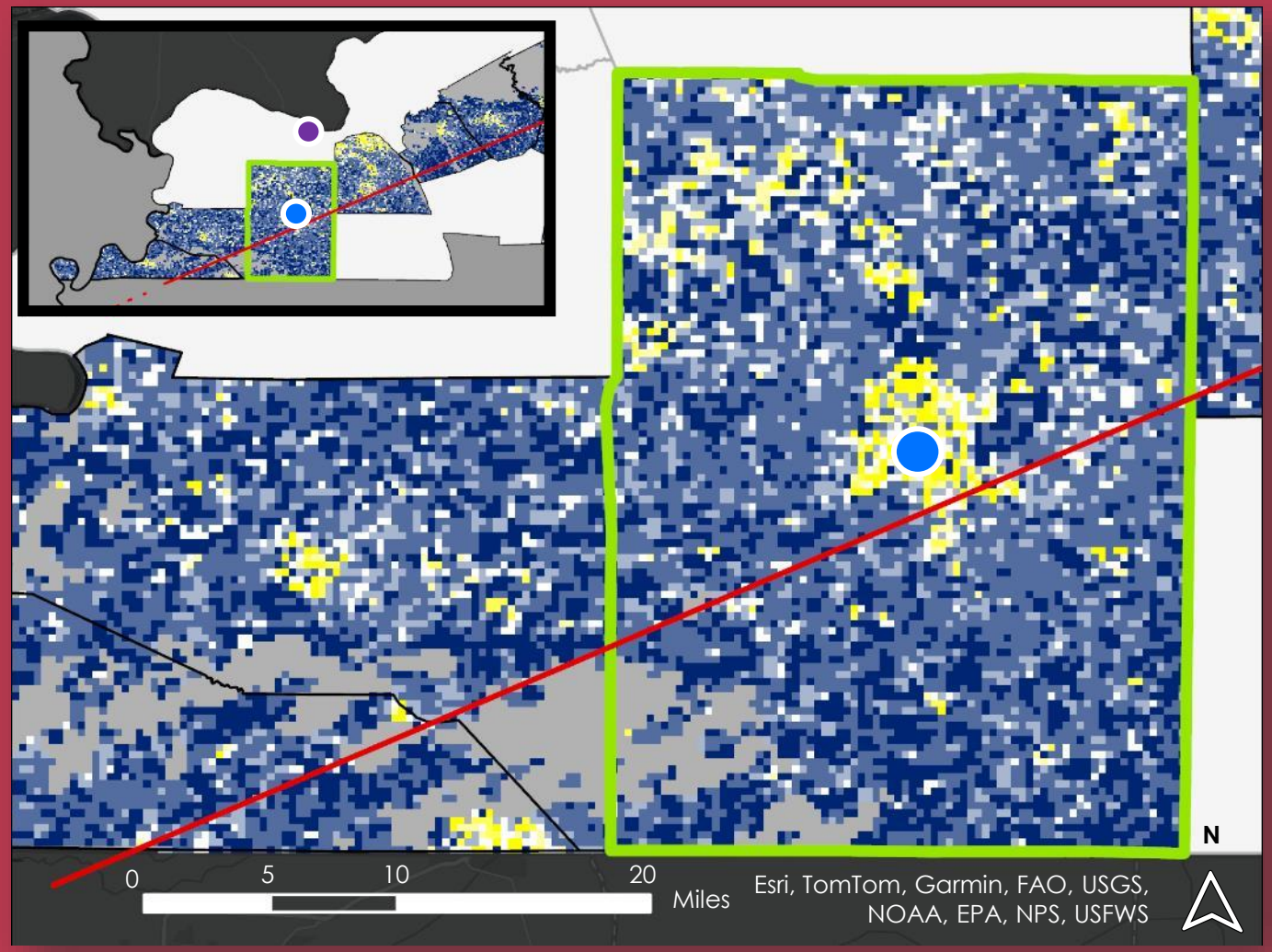
Change in Nighttime lights (NTL)
November 28 to December 11

Change in NTL Values

- 50 – 100% NTL **Increase**
- 25 – 50% NTL **Increase**
- 0 – 25% NTL **Increase**
- No Change
- 0 – 25% NTL **Decrease**
- 25 – 50% NTL **Decrease**
- 50 – 100% NTL **Decrease**
- Counties Impacted
- Western Kentucky Tornado Track
- Paducah
- Mayfield
- Kentucky Counties
- Graves County Boundary
- Cloud Cover

Date Tornado Occurred:
December 10 – 11, 2021

Graves County, Kentucky – Change in NTL Values



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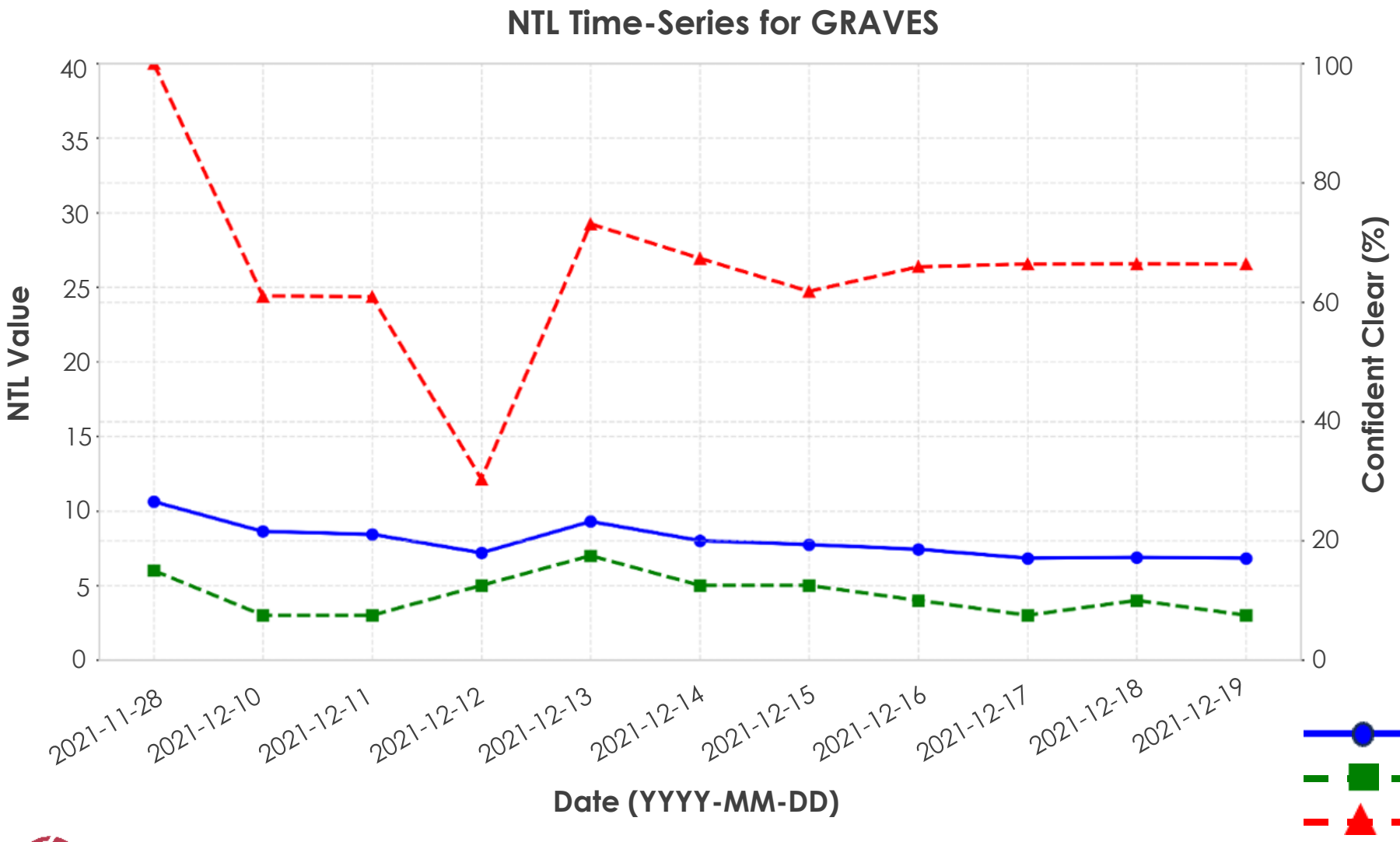
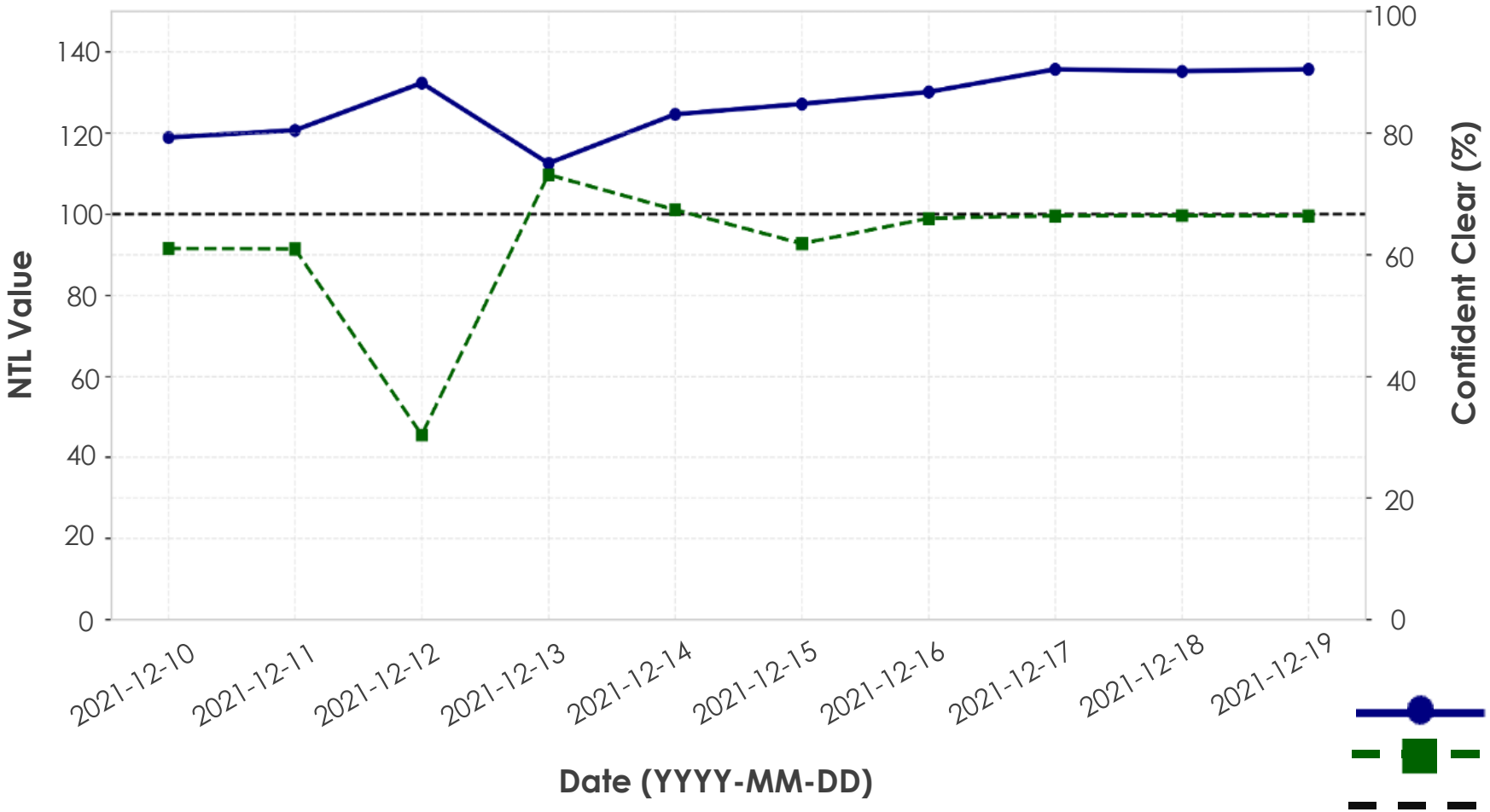
- Counties Impacted
- Western Kentucky Tornado Track
- Paducah
- Mayfield
- Kentucky Counties
- Graves County Boundary
- Cloud Cover

Graves County, KY - NTL Value Time Series



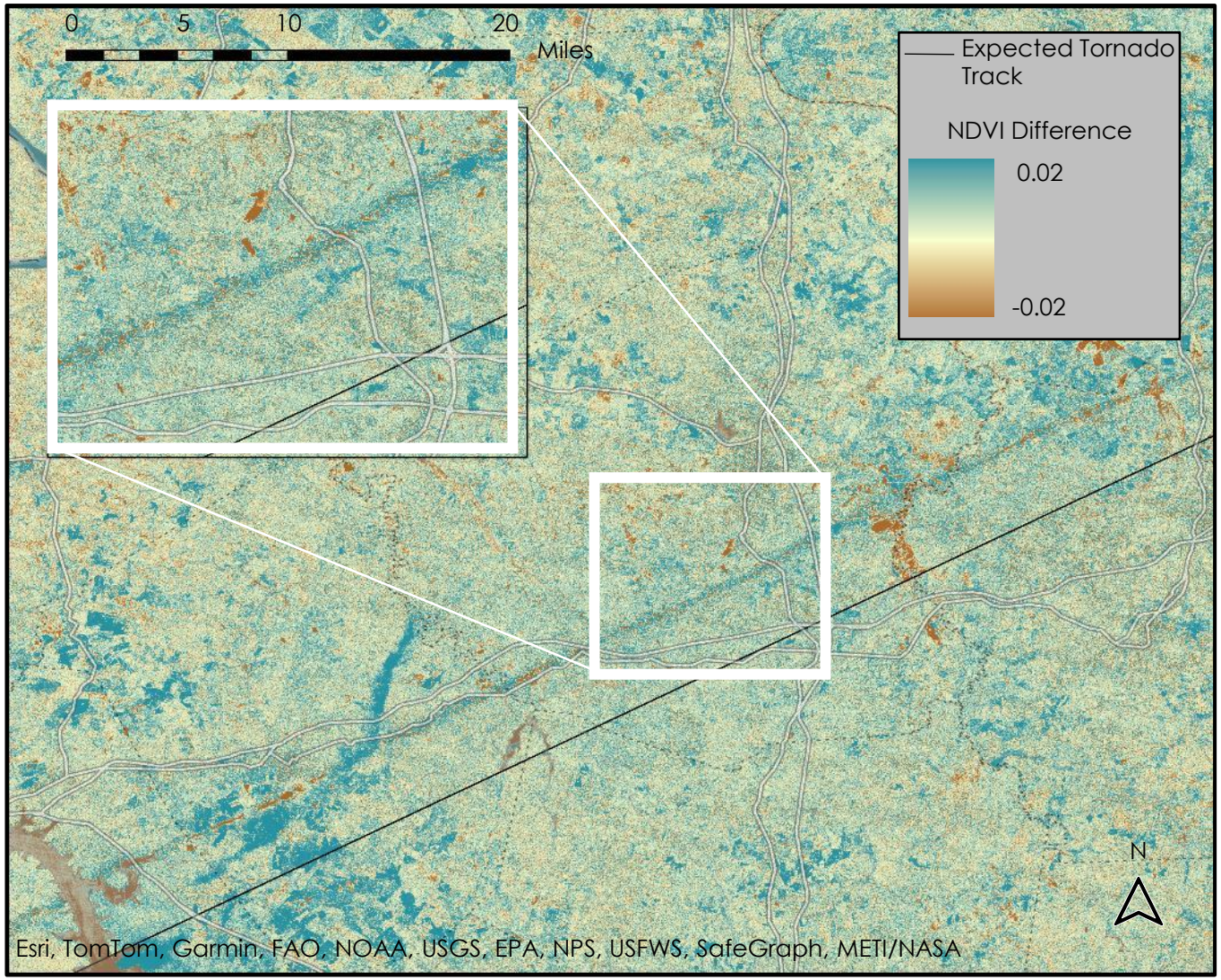
NTL analysis reveals a drop post-tornado, followed by gradual recovery, highlighting infrastructure impact and cloud cover variations affecting data reliability.

Graves County, KY - NTL Recovery Time Series



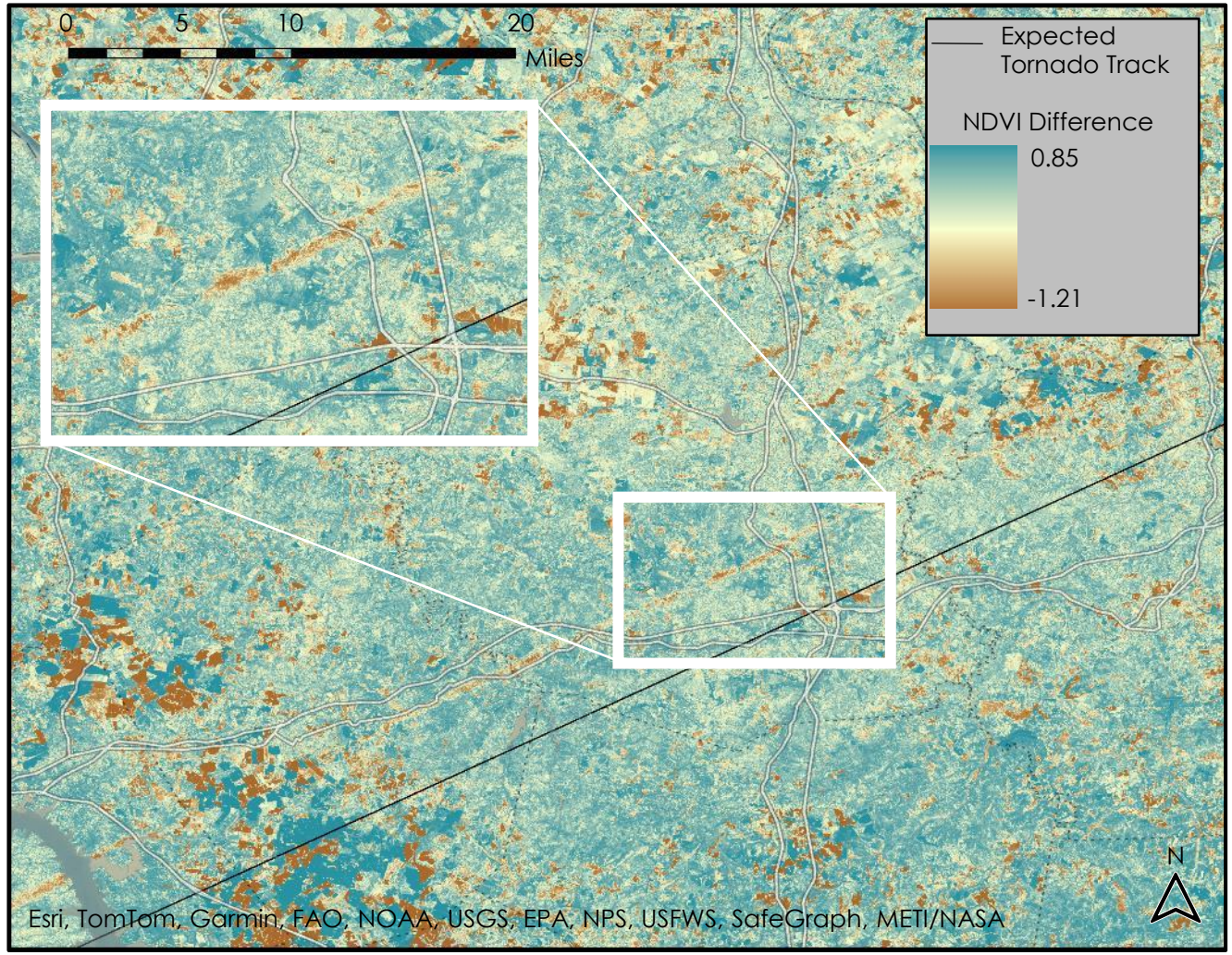
NTL recovery trend post-tornado shows initial disruption followed by gradual normalization, with cloud cover fluctuations influencing data visibility.

Western Kentucky Tornado: NDVI Difference Map



- Normalized Difference Vegetation Index (NDVI) shows damaged vegetation
- Difference between December 13th and December 8th
- Shows a false "green-up", an increase in NDVI across the tornado track, where NDVI *should* be decreasing
- Only visible on a very narrow range, 0.02 to –0.02

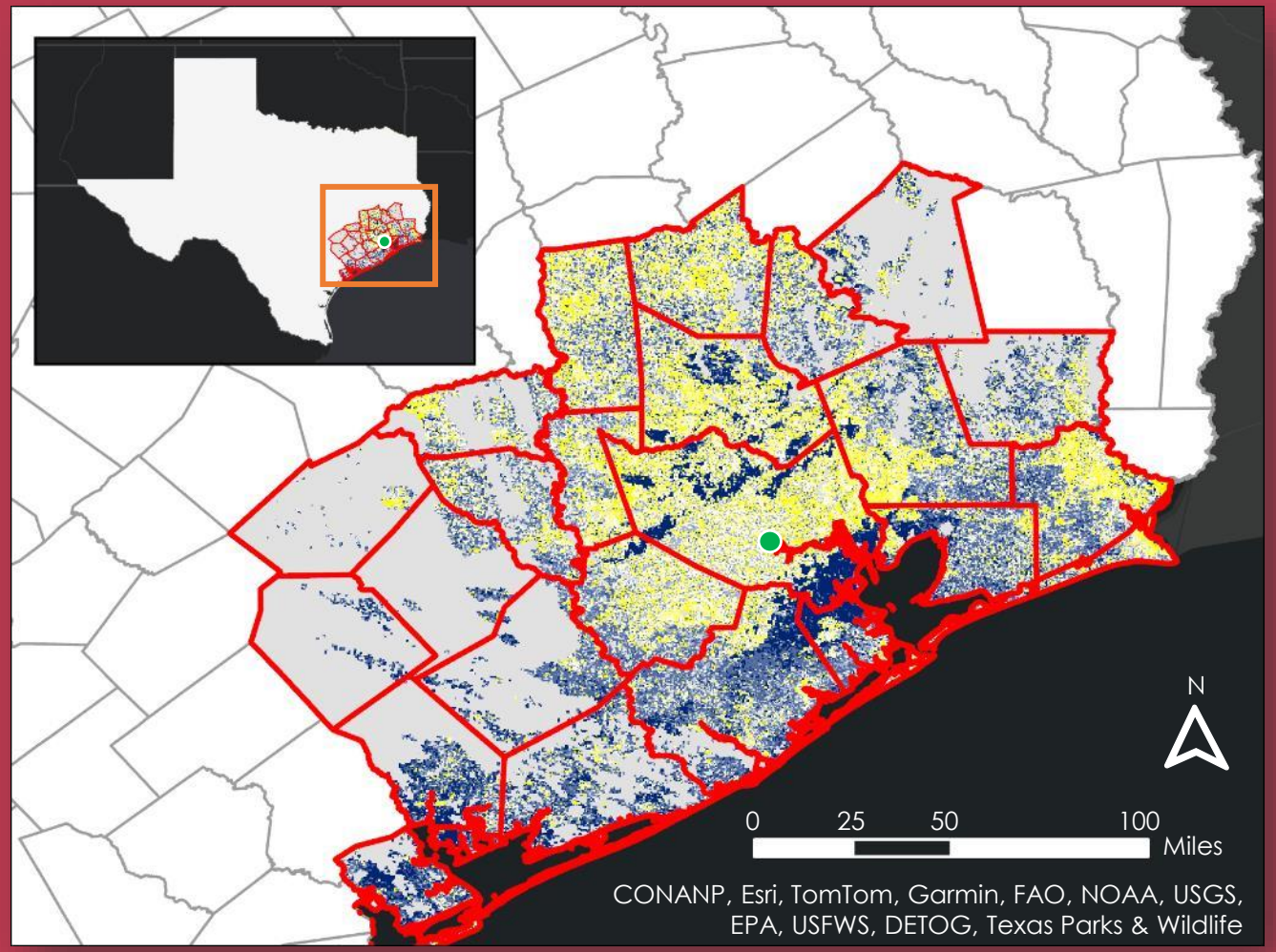
Spring NDVI Difference Map



- Springtime NDVI differencing fixes the false "green-up" problem
- This track was used to distinguish potentially damaged landcover

Land Cover	Percent	Area (km^2)
Tree Cover	64.46%	35.90
Grassland	15.21%	8.46
Cropland	12.99%	7.24
Built-up (Urban Areas)	0.93%	0.52
Bare/Sparse Vegetation	0.47%	0.27
Permanent Water Bodies	5.01%	2.80
Herbaceous Wetland	0.93%	0.52

Houston Derecho: Nighttime Lights



Change in Nighttime lights (NTL)
April 30 to May 17

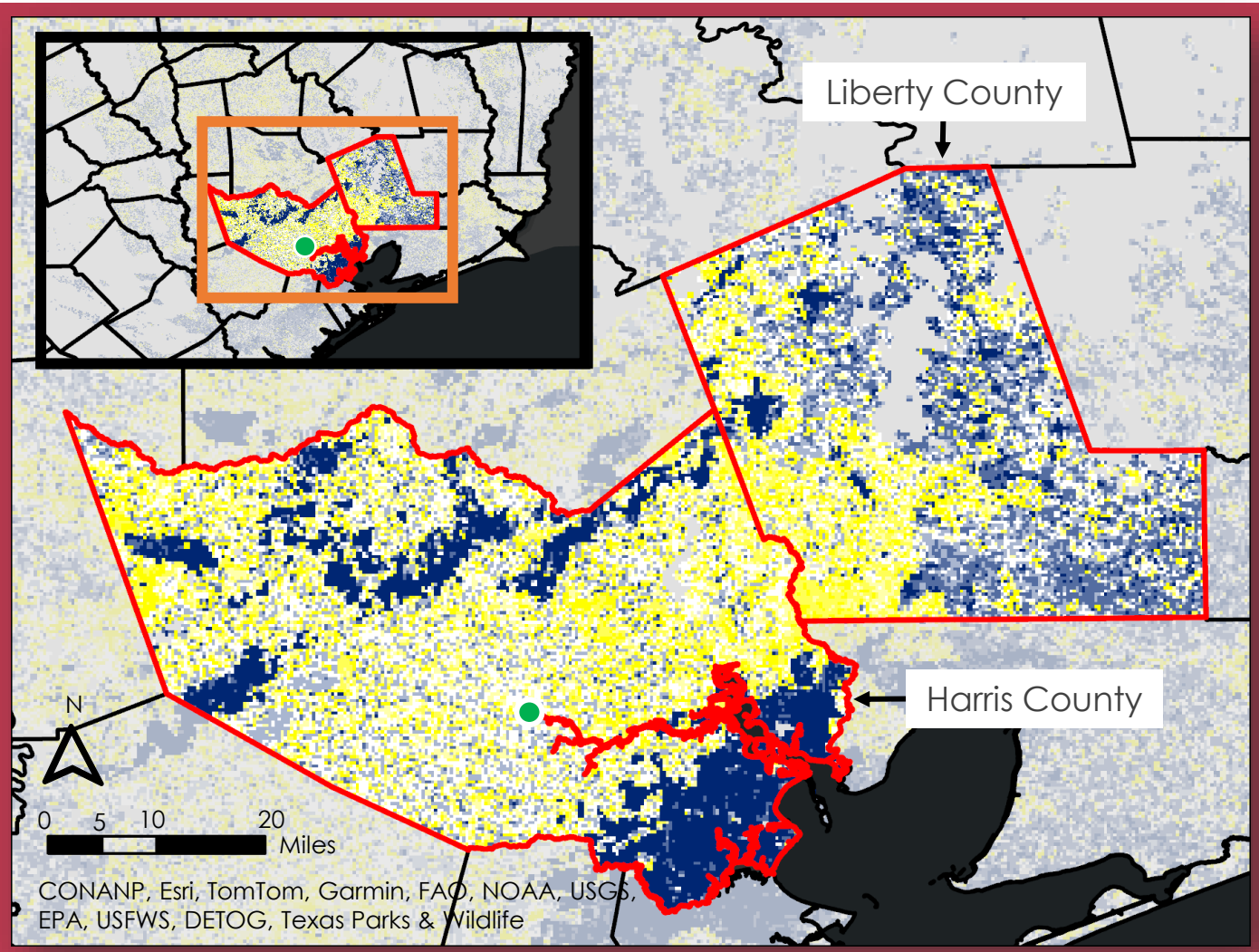
Change in NTL Values

- 50 – 100% NTL **Increase**
- 25 – 50% NTL **Increase**
- 0 – 25% NTL **Increase**
- No Change
- 0 – 25% NTL **Decrease**
- 25 – 50% NTL **Decrease**
- 50 – 100% NTL **Decrease**

- Houston
- TDEM Chief Region 4
- Texas Counties
- Cloud Cover

Date Derecho Occurred:
May 16, 2024

Texas Counties – Change in NTL Values



Change in Nighttime lights (NTL)
April 30 to May 17

Change in NTL Values

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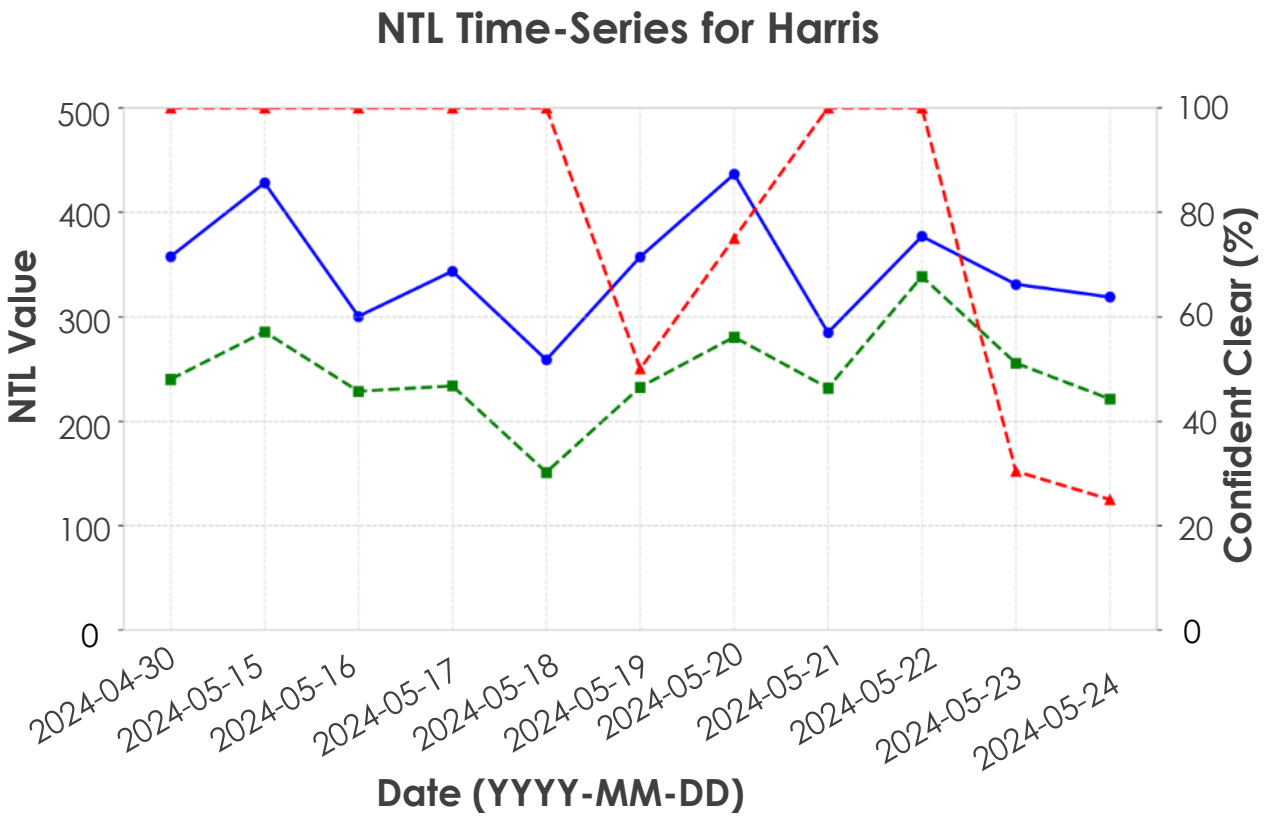
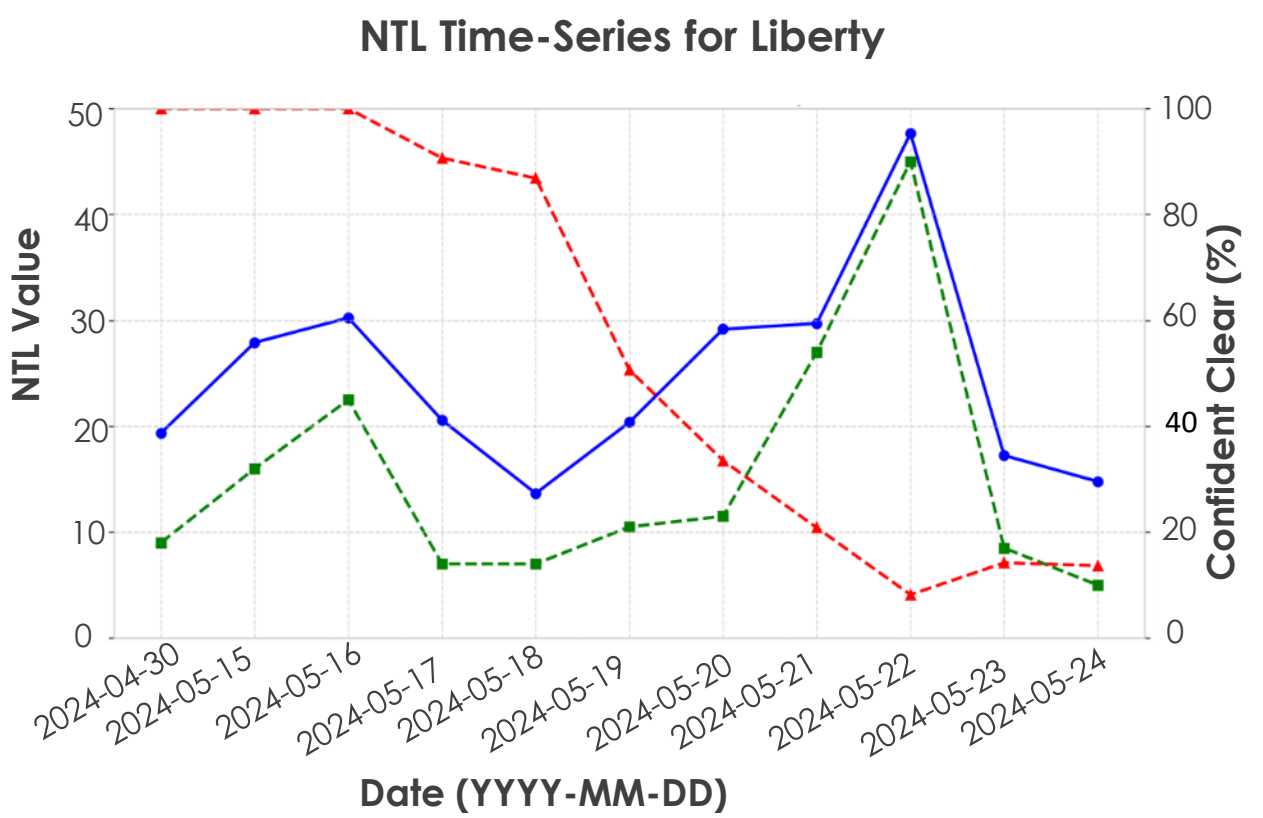
- No Change
- 0 – 25% NTL **Decrease**
- 25 – 50% NTL **Decrease**
- 50 – 100% NTL **Decrease**

- Houston
- Selected Counties
- Texas Counties
- Cloud Cover

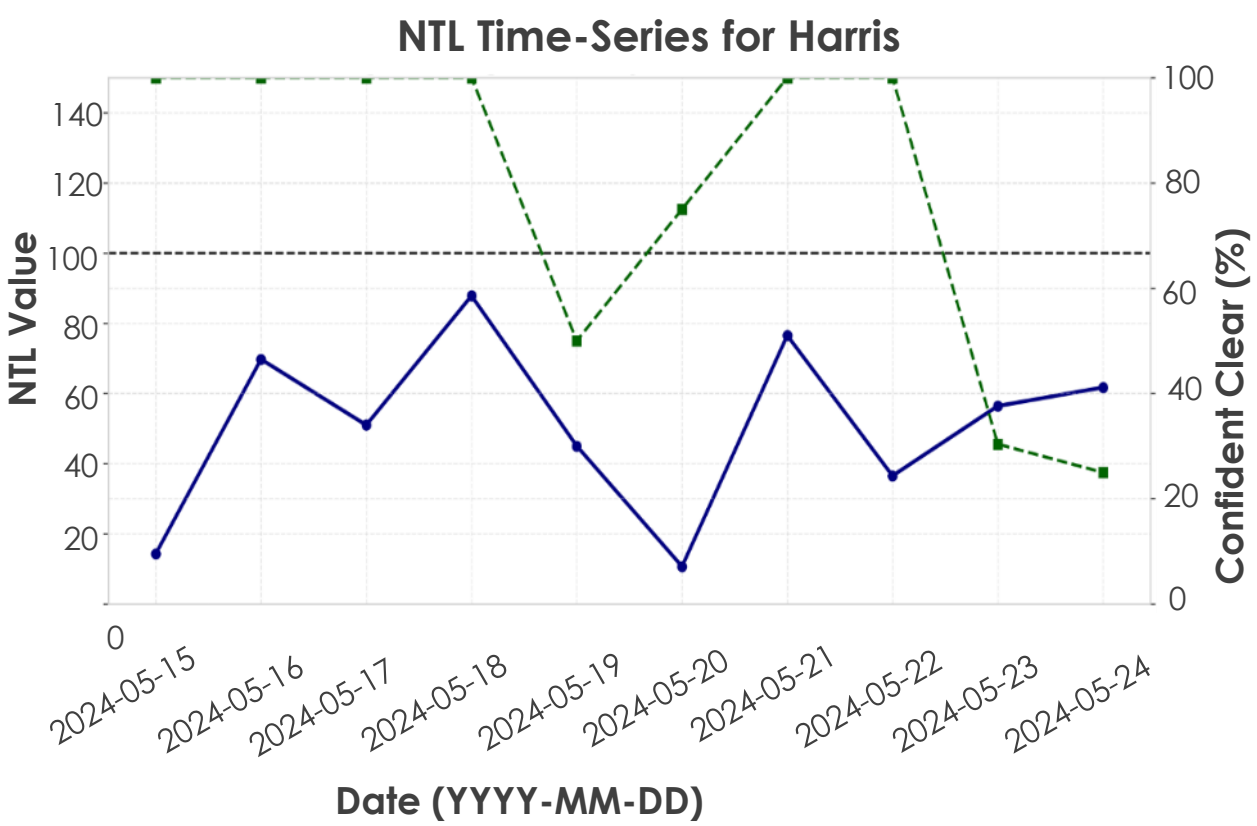
Texas Counties – NTL Time Series

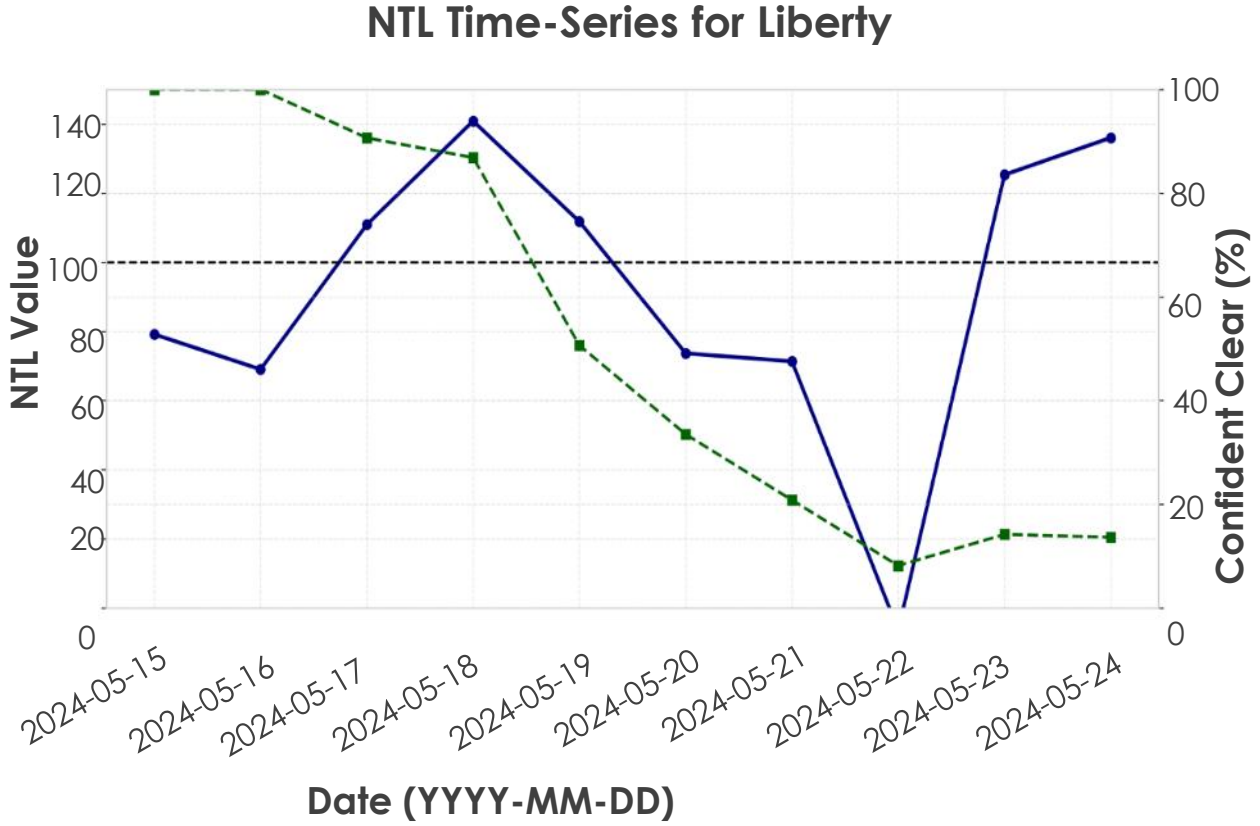




Mean NTL
Median NTL
Confident Clear (%)

Texas Counties – NTL Recovery Time Series

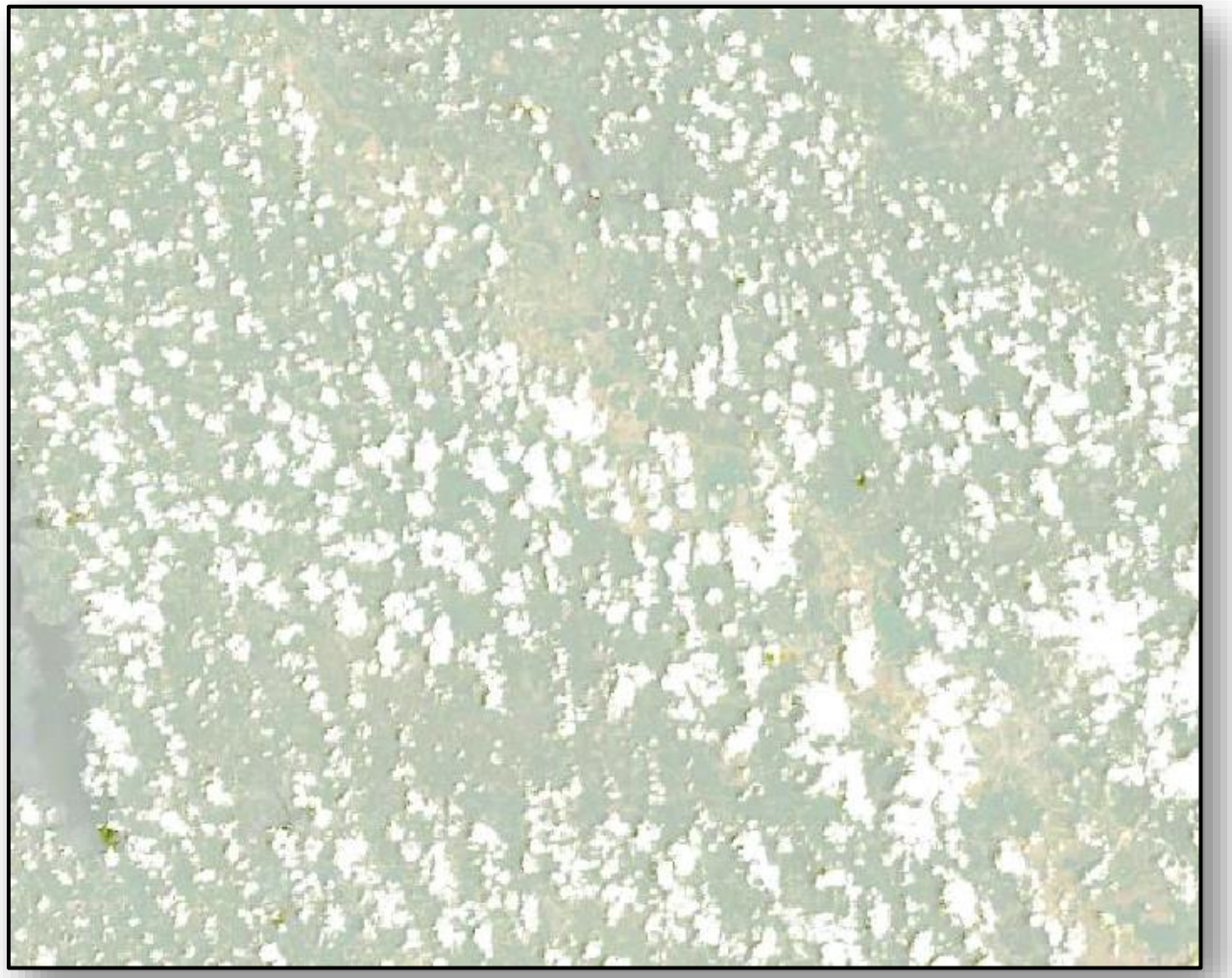




2024 Houston Derecho – *Sentinel-2*

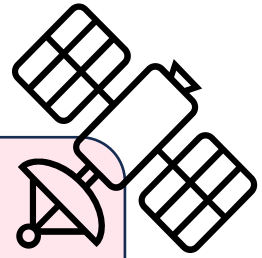
- Attempted to apply the same methodology to the Texas Derecho
- Sentinel-2 imagery was highly cloud contaminated, evident on May 20th image
- Cumulus clouds can obscure storm damage by covering the vegetation

2024 Houston Derecho – *Landsat-8*



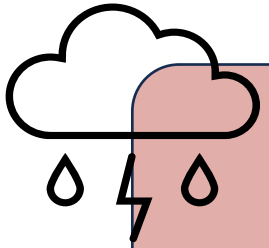
- Imagery from May 20th was some of the only post-storm imagery available under 25% cloud cover
- Obtaining pre-event imagery was equally difficult due to cloud contamination
- Climatological distinctions prevent application of the Kentucky Method

Limitations



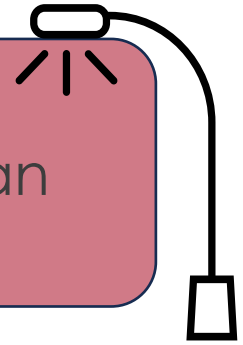
Coarse Spatial Resolution from Landsat and Sentinel-2

- High resolution (~ 1 m) data are desired to monitor vegetation damage due to disasters



Cloud Contamination

- Obscured imagery near dates of event
- Affected NTL time series and recovery graphs



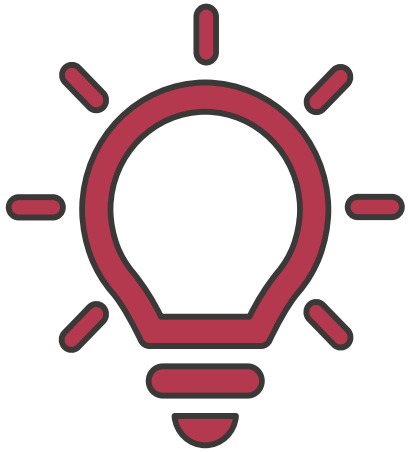
NTL Brightness

- Pre-event image selection is crucial. Poor choices can misrepresent actual damage

Conclusions

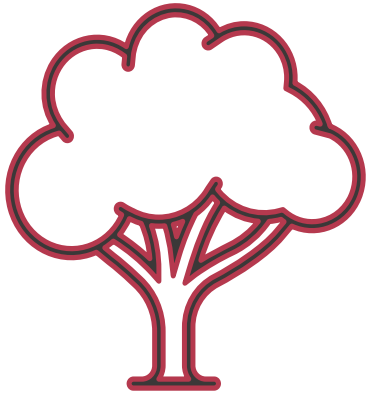
Identify damage extent through power outages

- NTL data can be used to detect areas of damage post-disaster in highly populated urban areas. Cloud cover should be considered to monitor NTL change.



Identify damage extent through vegetation damage

- Vegetation analysis can be used to detect areas of damage post-disaster in rural areas where NTL data was limited.
- Vegetation analysis was better for narrow damage extent events compared to widespread damage extent events.



Demonstrate if Earth observations are informative for post-disaster analysis of rural and urban areas

- Earth observations can be informative depending on type of event and seasonality.

Acknowledgements

- Science Advisors
  - **Dr. Shenyue Jia** (Assistant Professor of Geography at Miami University)
  - **Robbyn Abbitt** (GIS Coordinator and Associate Director of Geospatial Analytics Center at Miami University)
  - **Dr. David Prytherch** (Professor of Geography at Miami University)
- Center Lead
  - **Ella Haugen** (NASA DEVELOP National Program, Virginia – Langley)
- Project Partners
  - **Melissa Ruiz**, Unit Chief, Geospatial & Data Analyst (Texas Division of Emergency Management)
  - **Chris Noles**, Science and Operations Officer (National Weather Service, Paducah, KY)

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  - This material contains modified Copernicus Sentinel data 2021 and 2024, processed by ESA
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  - **Patrick Kerwin**, Intern, NASA's Disaster Response Coordination System Intern (NASA Langley)
  - **Patrick Rea**, Geospatial Lead, NASA's Disaster Response Coordination System Intern (NASA Langley)
  - **Dr. Xia Cia**, Program Scientist (NASA Langley Research Center)

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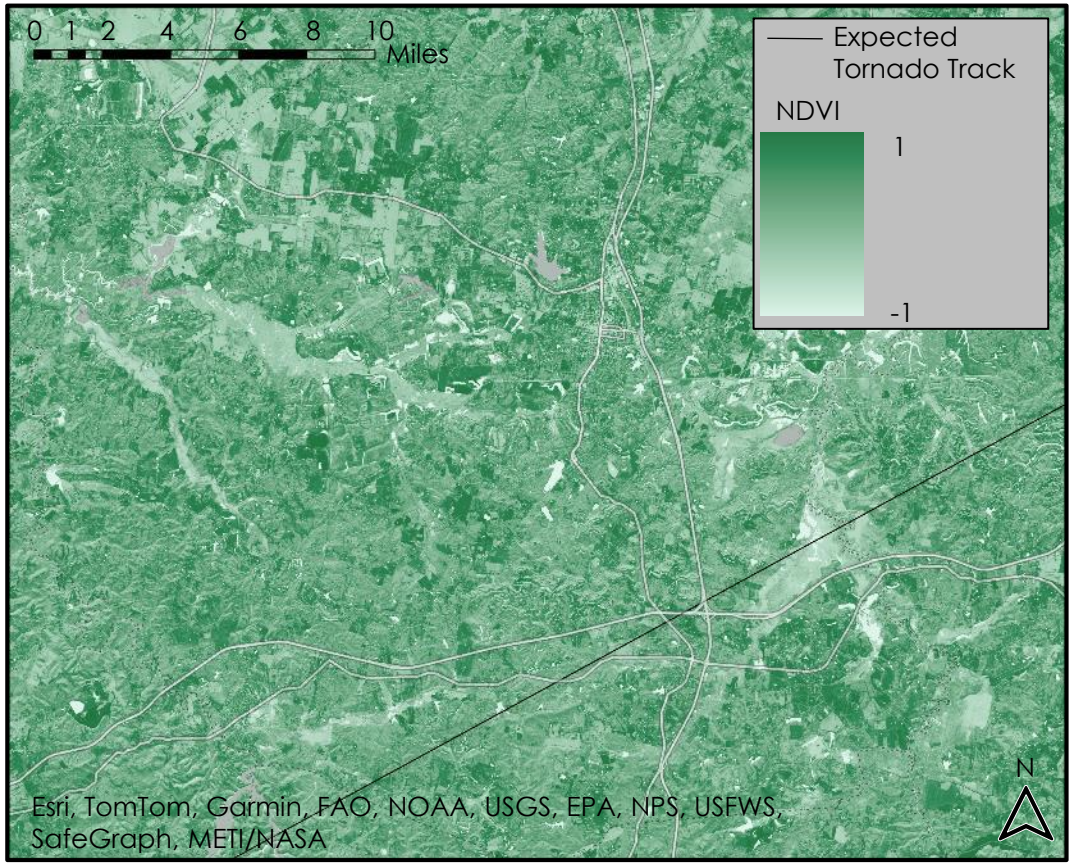
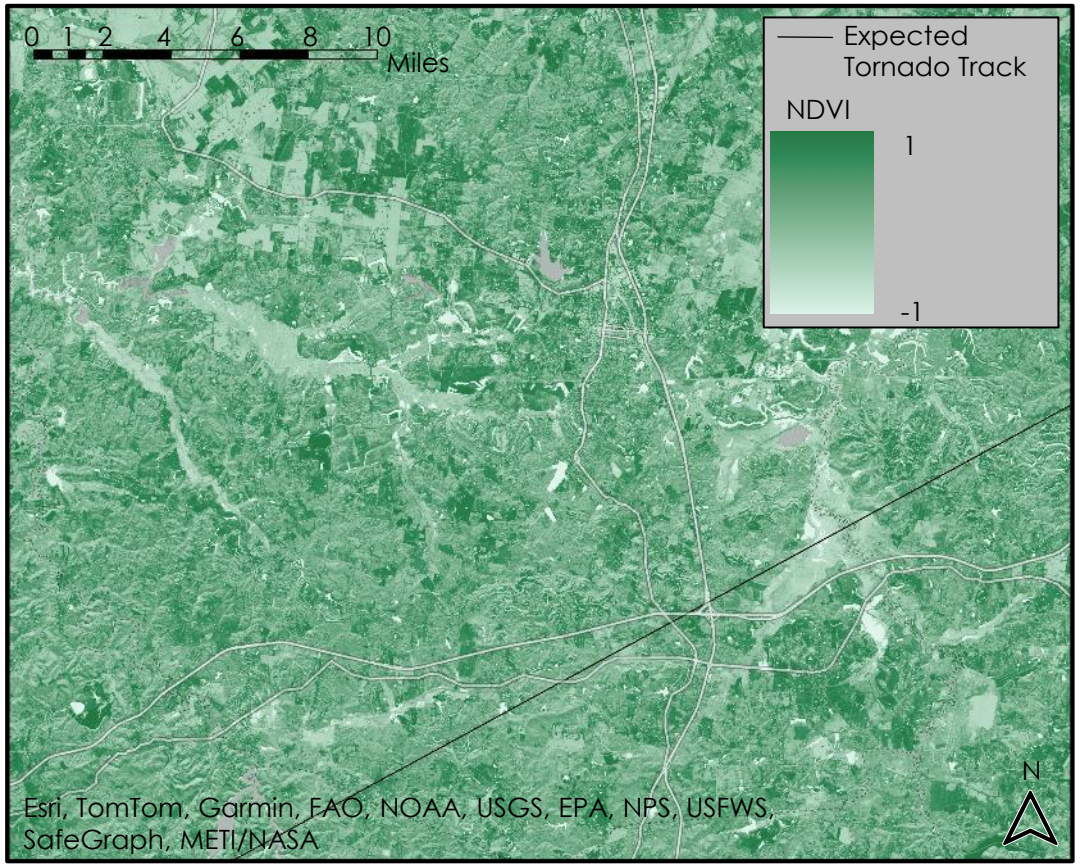
Western Kentucky Tornado: Normalized Difference Vegetation Index (NDVI)

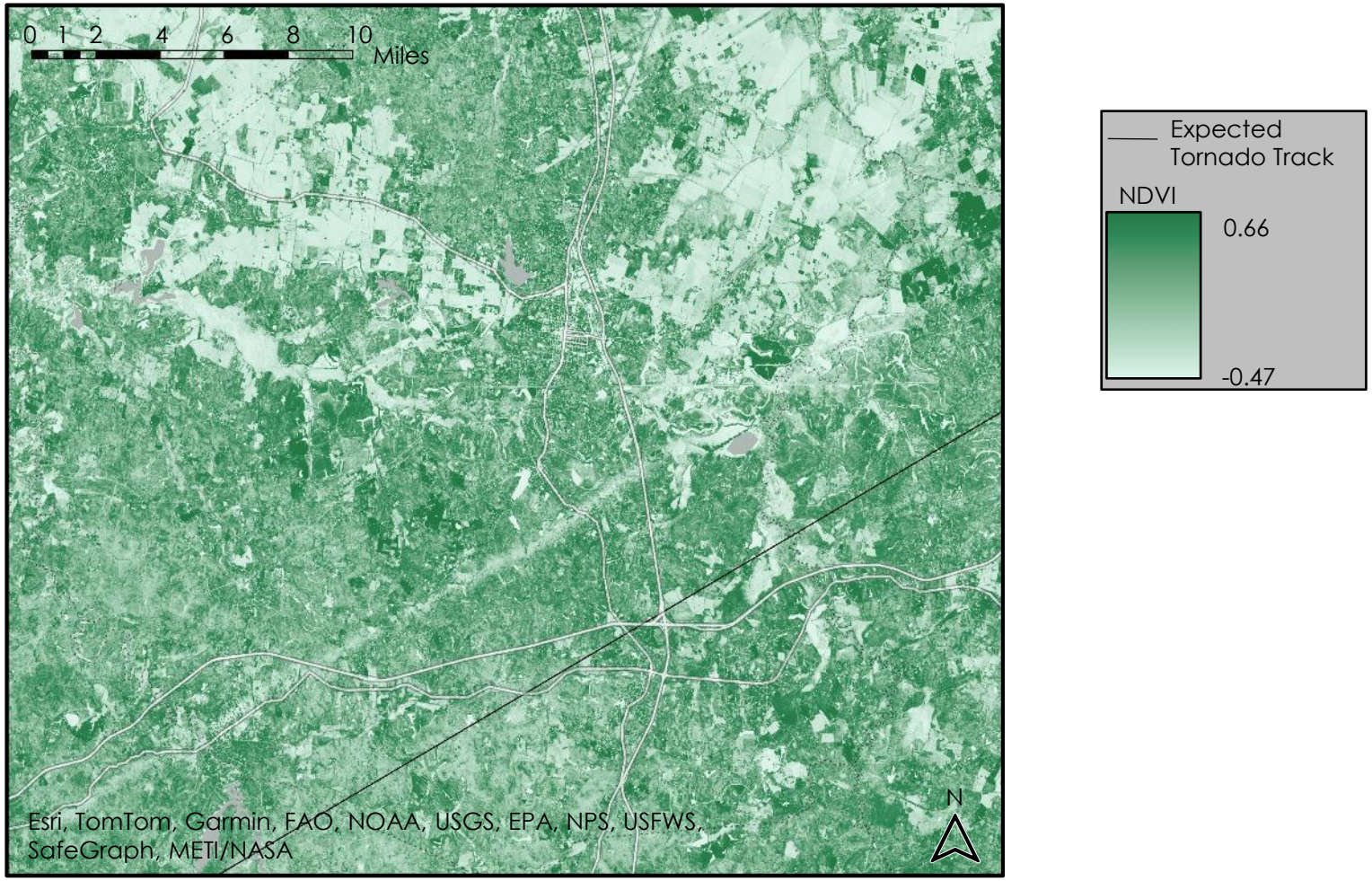
December 8th NDVI



December 13th NDVI



Spring 2022 NDVI Shows Track Pre-Differencing



Kentucky Tornado: Spring NDVI Difference in Track-Break Region