Examining Severe Weather Damage and Flood Impacts through Synthetic Aperture Radar and Optical Imagery from the ESA Sentinel Missions

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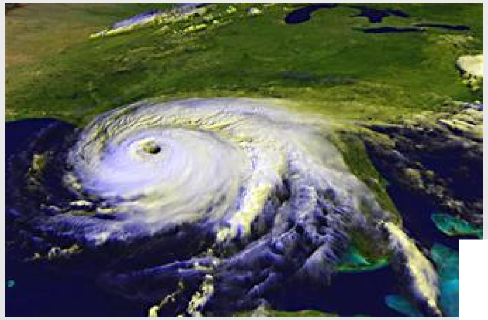
Applied Science and Disaster Response at NASA

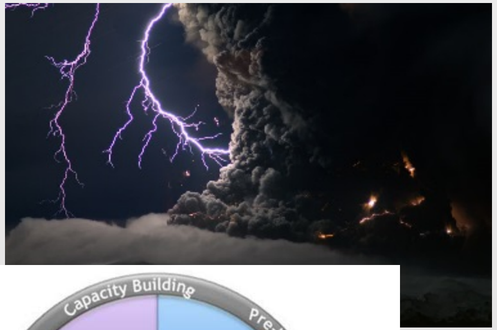
Science Mission Directorate
Earth Science Division

NASA Earth Science

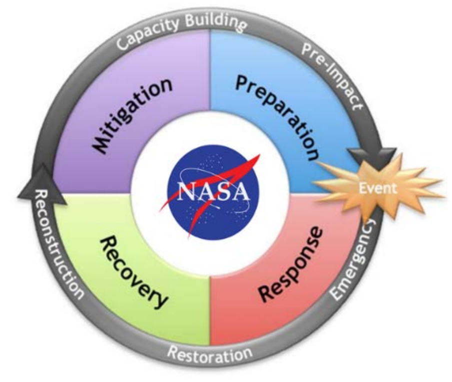
- Research
- Applied Science
- Flight
- Technology

Partnerships
&
International Initiatives





Disaster Response



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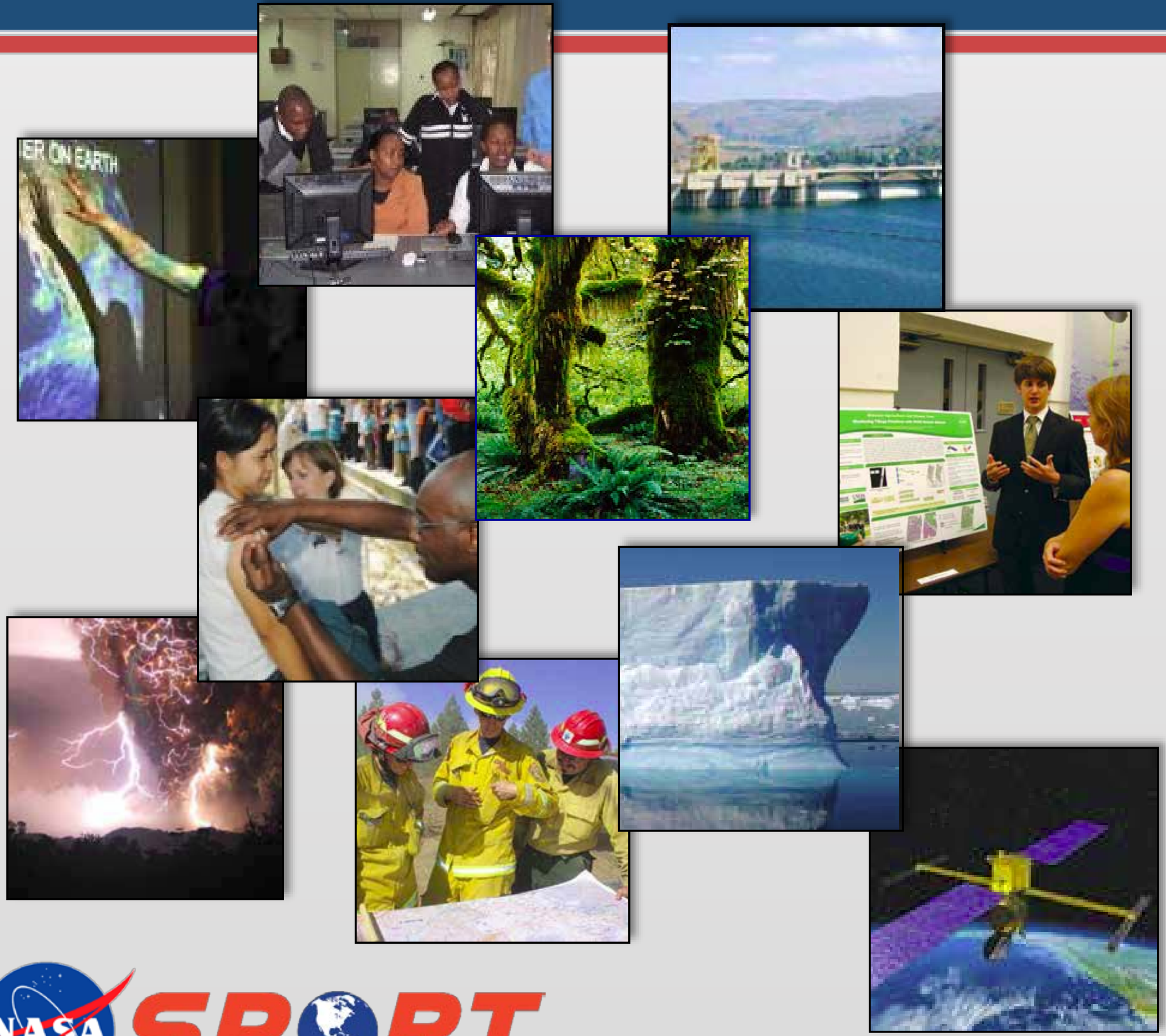
Application Themes & Societal Benefit Areas



Programmatic Focus on:

- Health & Air Quality
- Disasters
- Water Resources
- Wildfires
- Ecological Forecasting

Support ad hoc opportunities in additional areas:

- Agriculture & Food Security
- Aviation Safety
- Climate & Weather
- Energy
- Socioeconomic Impacts

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The NASA SPoRT Paradigm

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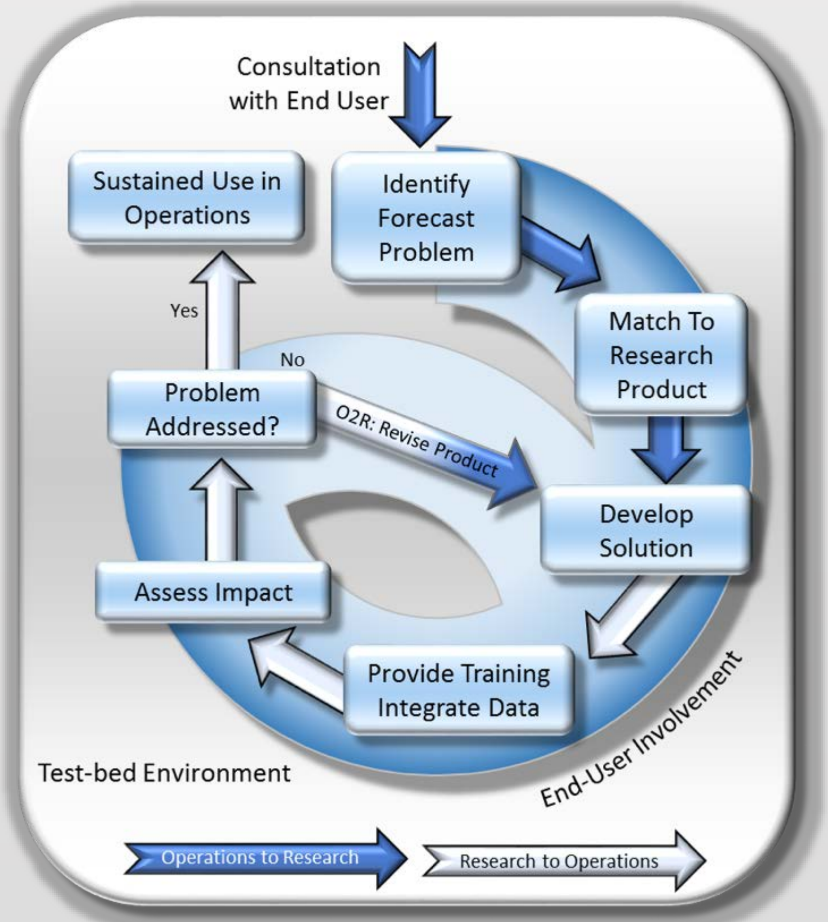
<u>Keys to success</u>

- **Involve** end users throughout the entire process.
- **Develop** end-user appropriate training on how to understand and correctly use the solution that has been developed
- **Assess** impact of solution on operations

A successful transition occurs when a new capability has a predominately positive impact on the forecast problem and is used “operationally” in the end users decision support system.

“Operational” use means regular or sustained use of data / products to make decisions



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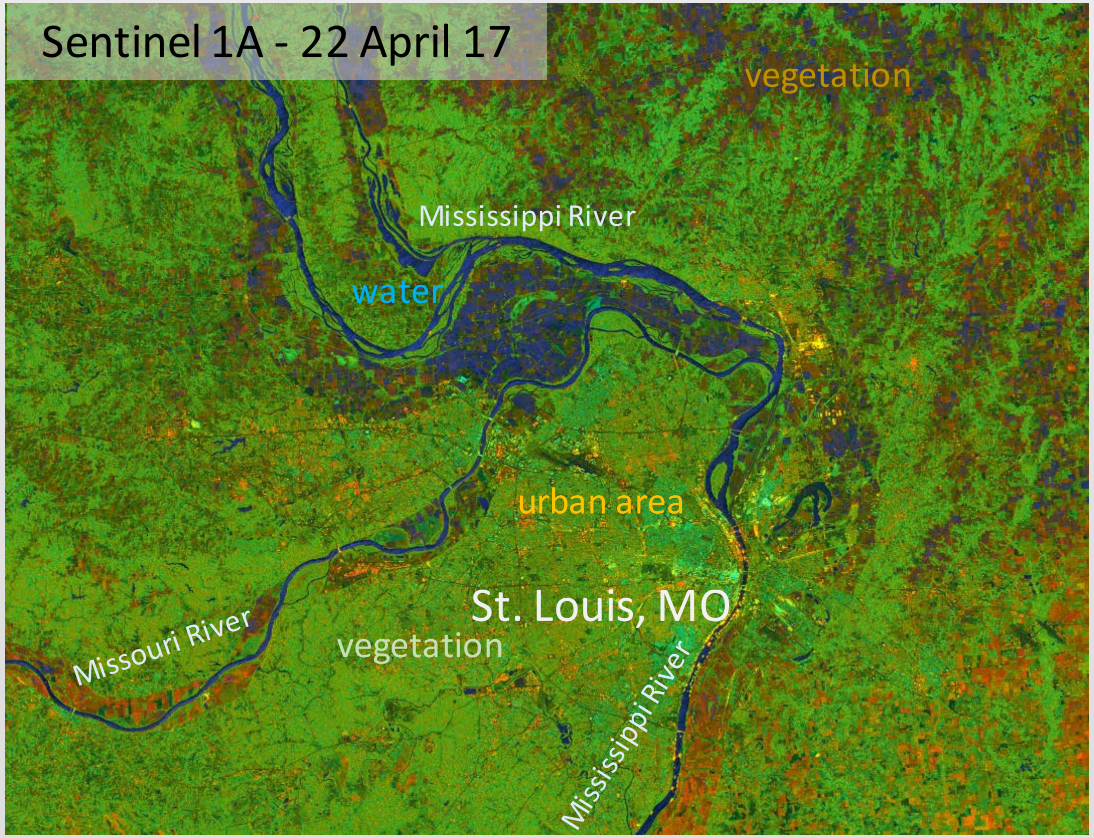
Missouri Floods of Spring 2017

SAR products from Sentinel 1A/1B are useful for the visualization of flood water, urban area, and vegetation given unique appearances in co- and cross-pol returns.

Collaborations with the University of Alaska Fairbanks provide RTC and false color combinations to aid in interpretation.

In this image, Sentinel 1A false color imagery captures flooding along the Mississippi and Missouri Rivers near St. Louis, Missouri in late April 2017.



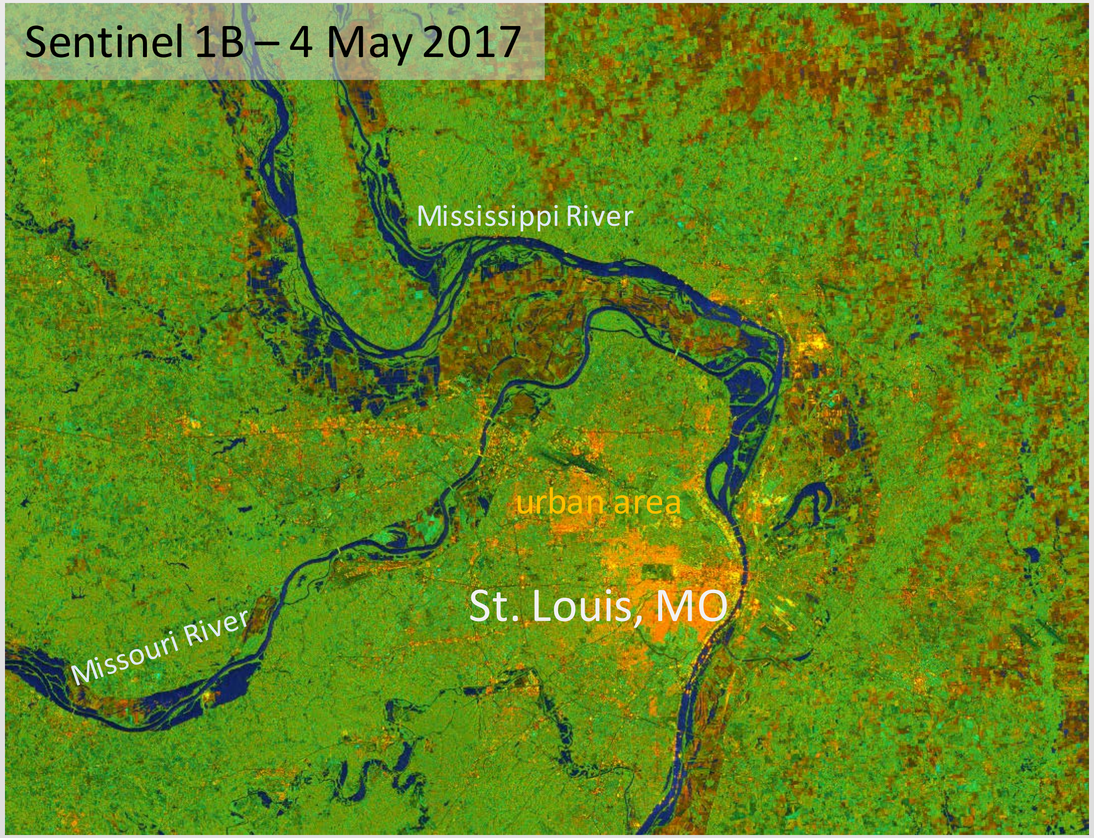
Sentinel 1A false color composite obtained on 22 April 2017 near St. Louis, Missouri

Missouri Floods of Spring 2017

False color compositing allows for rapid, visual identification of key features.

Changes in false color composites over time also help to visually interpret and confirm changes in water extent as flooding progresses downstream, and other flood waters recede. Some caution must be used regarding changes in viewing angle and time of day.

SAR products can be used in combination with optical imagery to improve understanding of current conditions.

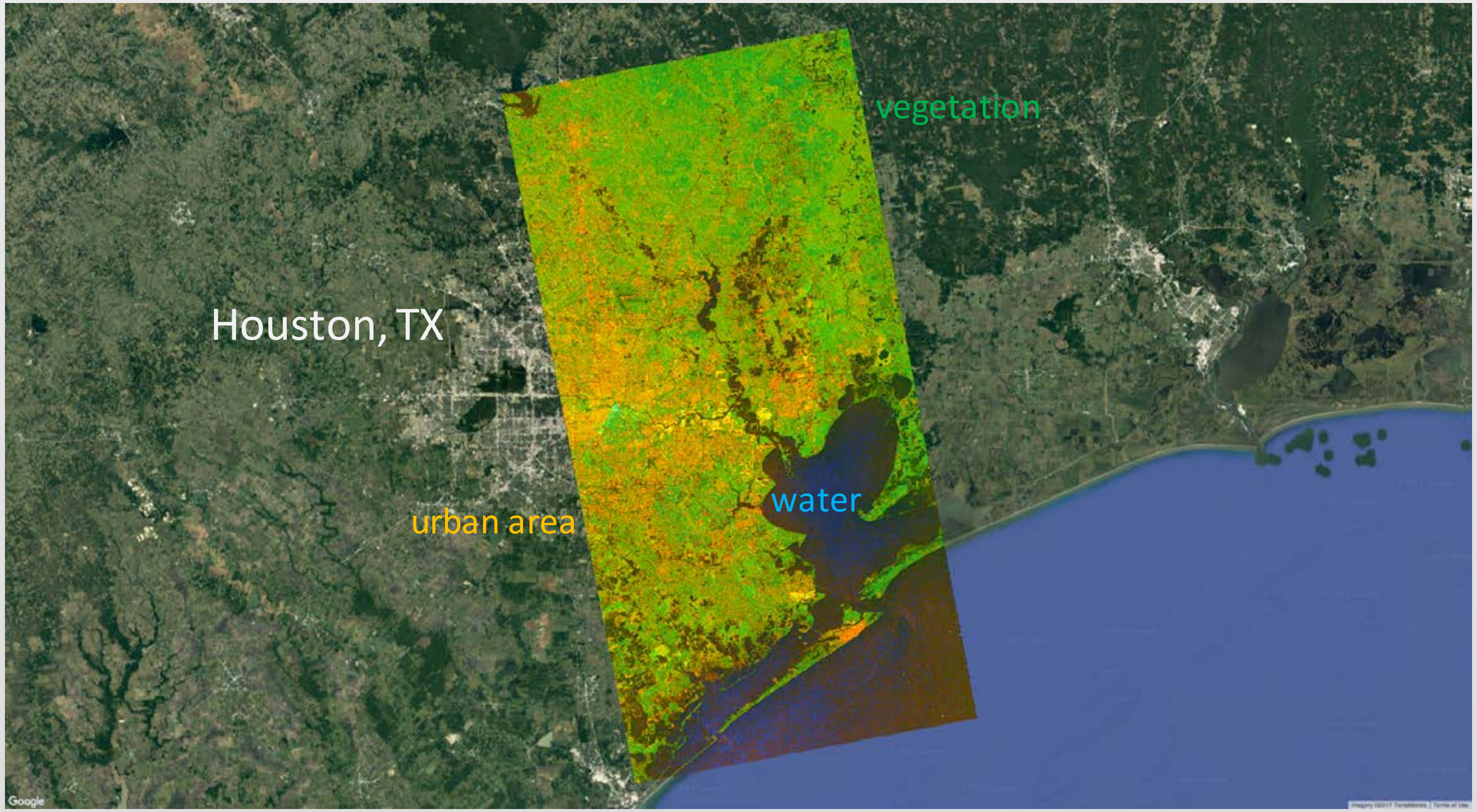


Sentinel 1B false color composite obtained on 4 May 2017 near St. Louis, Missouri

Flooding from Hurricane Harvey

Applications of SAR imagery have been extensive following major hurricane landfalls in the United States and Caribbean.

In this image, S1B stripmap mode imagery of the Houston, TX area captures coastal and inland flooding in dark shades of blues and browns.



Sentinel 1B false color composite obtained on August 30, 2017 at 0017 UTC.

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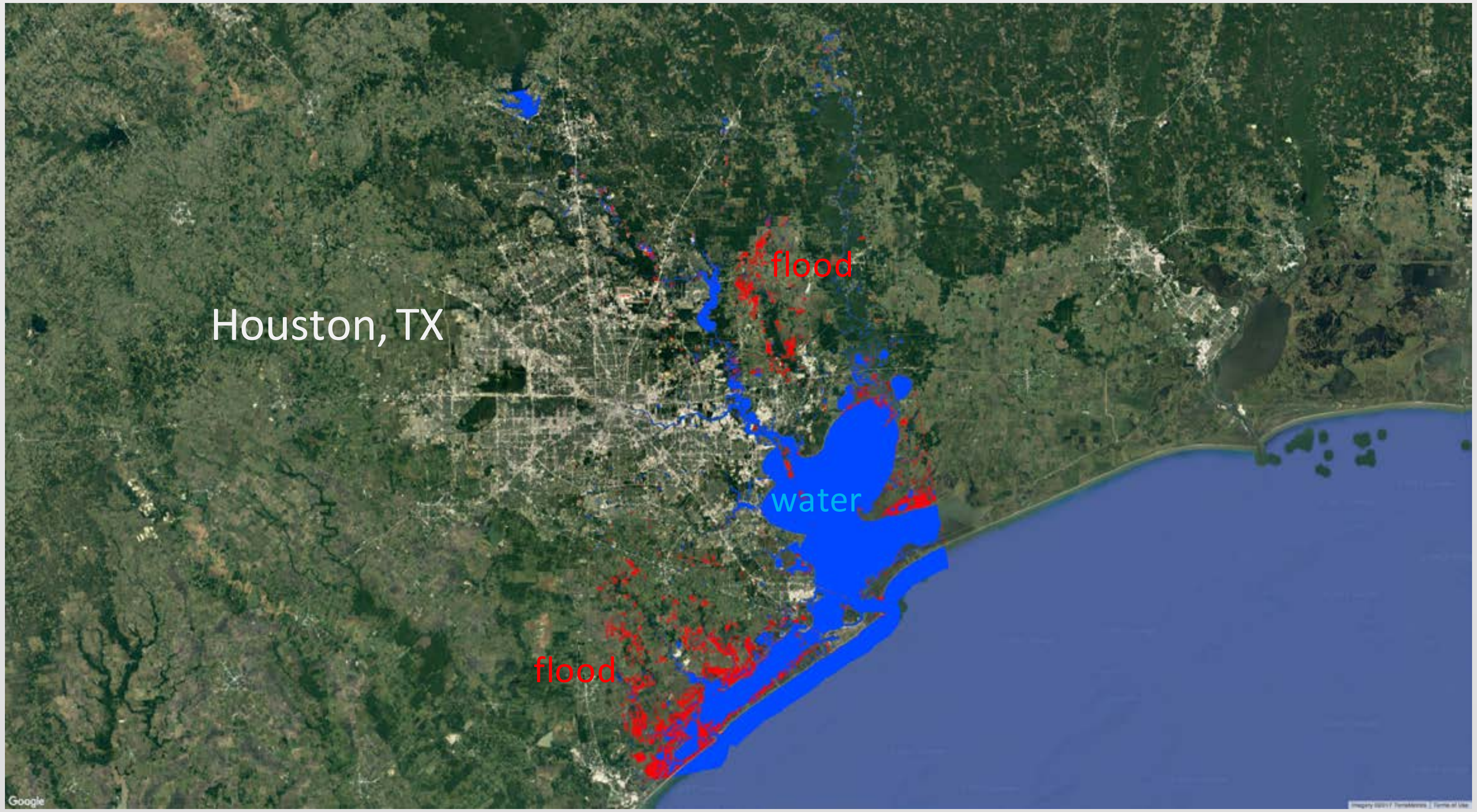
Flooding from Hurricane Harvey

Single, post-event scenes can be used with thresholding approaches to quickly mask water.

Statistics for known, open water in the area were used as guidance to select a threshold.

With threshold selected, flood is identified as water outside of known water areas.

Identifying flooding that occurs beneath vegetation and rapid, robust change detection work continues.



Sentinel 1B single-image, threshold-based flood detection from August 30, 2017 at 0017 UTC.

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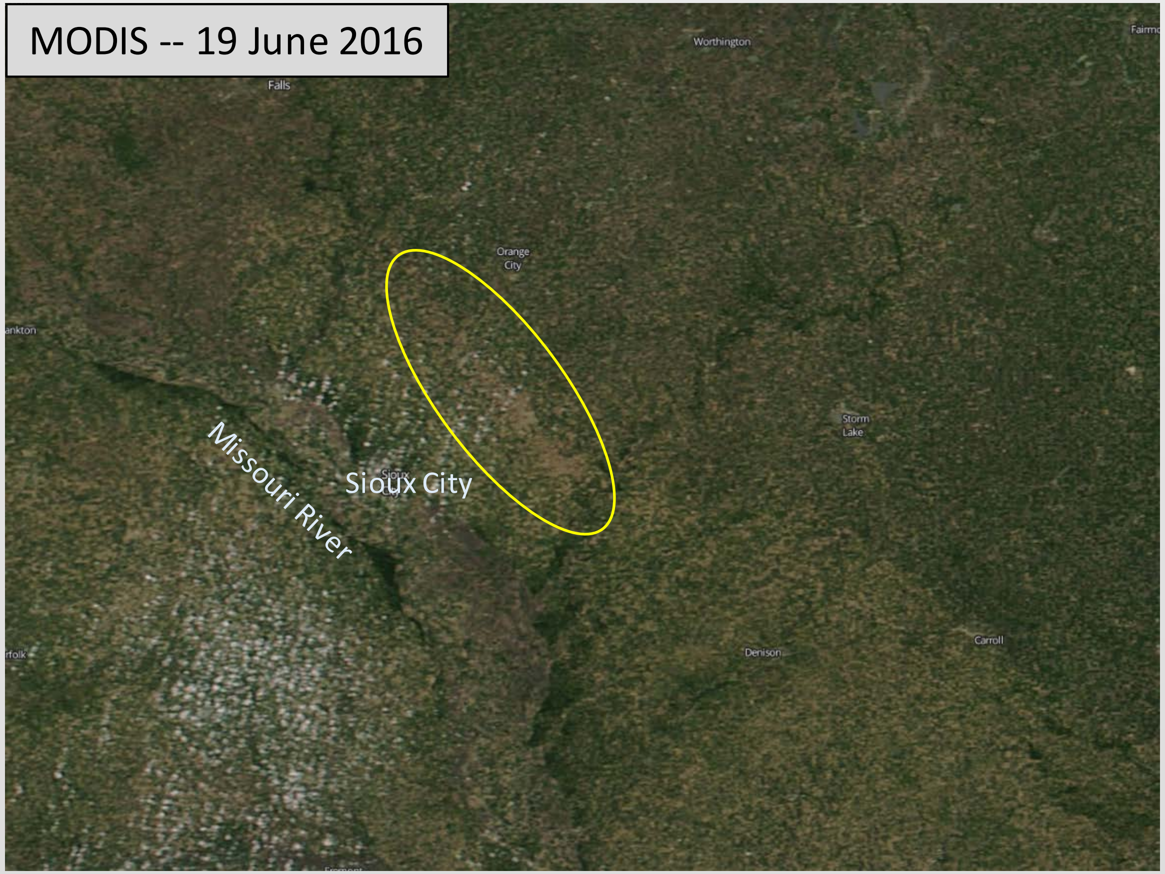
Wind-driven Hail Damage to Crops

Severe thunderstorms in the Central U.S. bring combinations of large hail, damaging winds, and tornadoes during the primary growing season months of June through August.

Here, a brown “hail damage scar” is seen in northwestern Iowa, the result of gusty thunderstorm winds, hail, and tall corn crops that are susceptible to hail damage.

True color imagery from MODIS captures the damage the following day as the loss of green vegetation and browning/decay that remains.



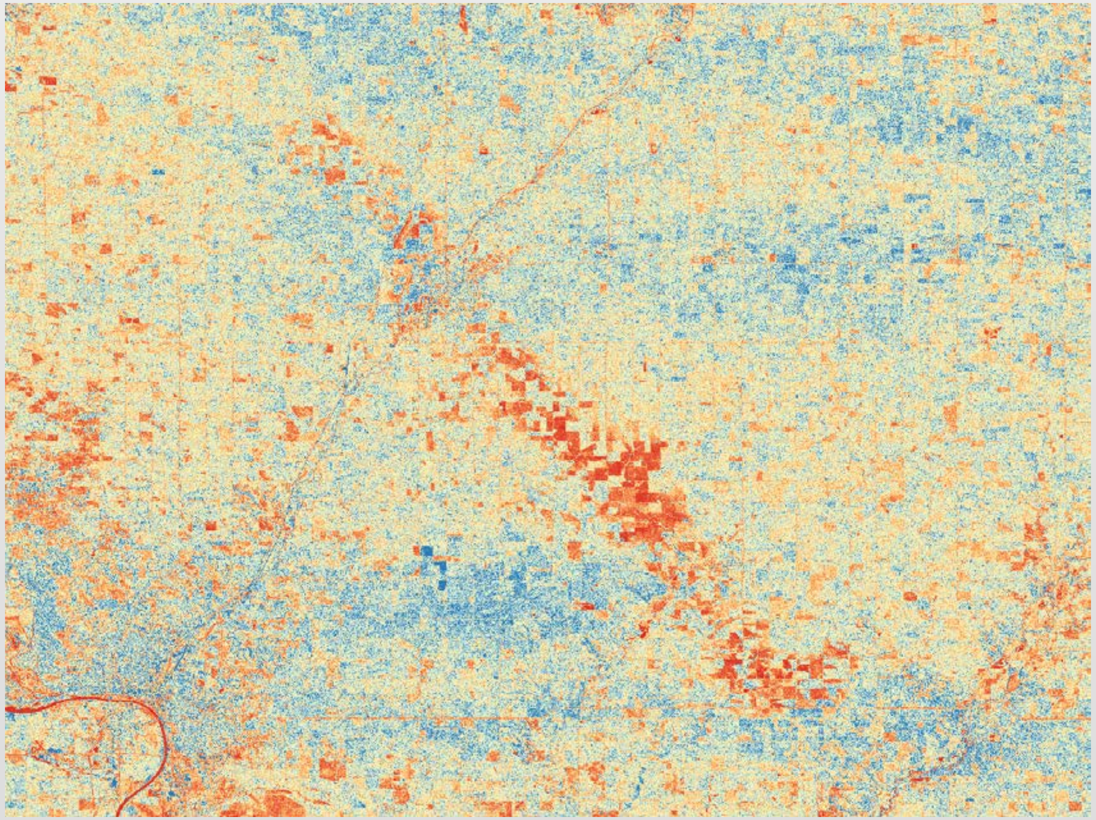
Terra MODIS true color imagery captures a hail scar on 19 June 2016.

Wind-driven Hail Damage to Crops

In cross- and co-polarized imagery, damage to corn in the Midwestern U.S. is often apparent as sharply reduced values, particularly when compared to other undamaged corn fields.

SAR imagery resolves field-scale differences as a patchwork of anomalies, where other crops that were less susceptible to hail damage (shorter row crops, etc.) do not exhibit as significant of change.

Preliminary work examines anomalies for these crops and maps areas of the most severe damage attributable to rapid change.



Colorized VH amplitude image highlighting decreased values in hail-damage area.

Wind-driven Hail Damage to Crops

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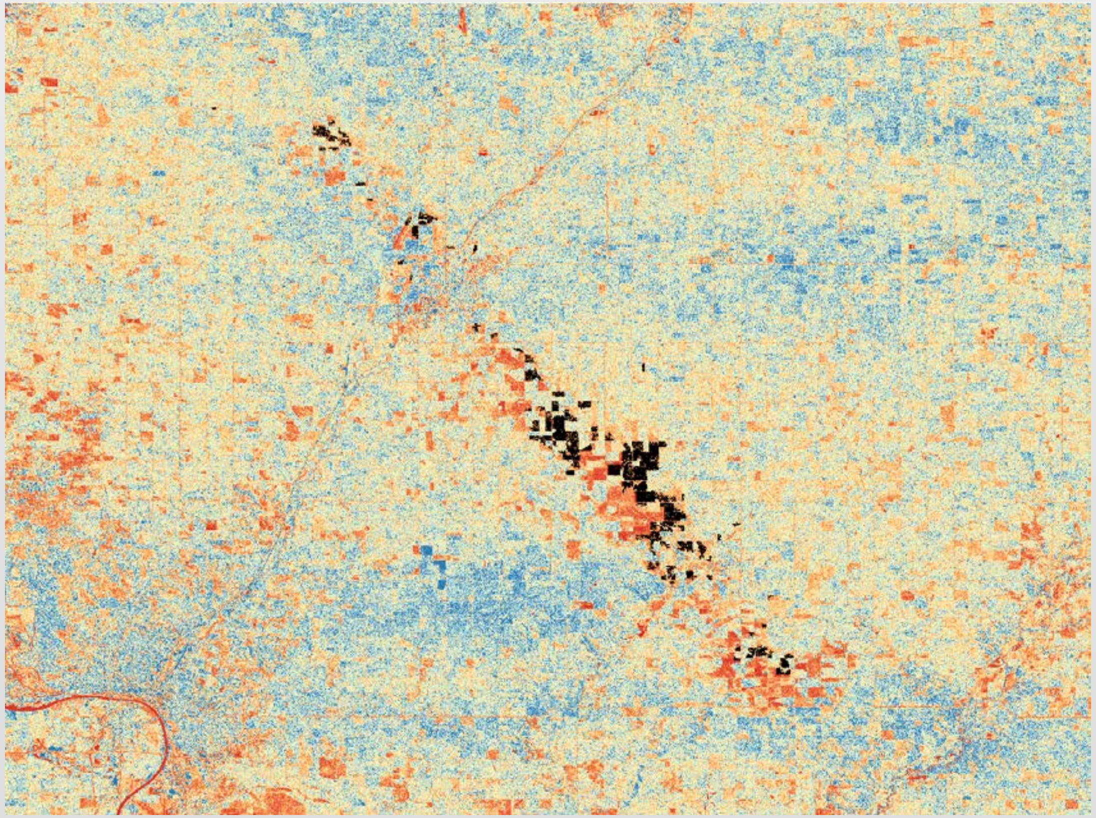

Preliminary identification of the most severe hail damage/change from VH only.

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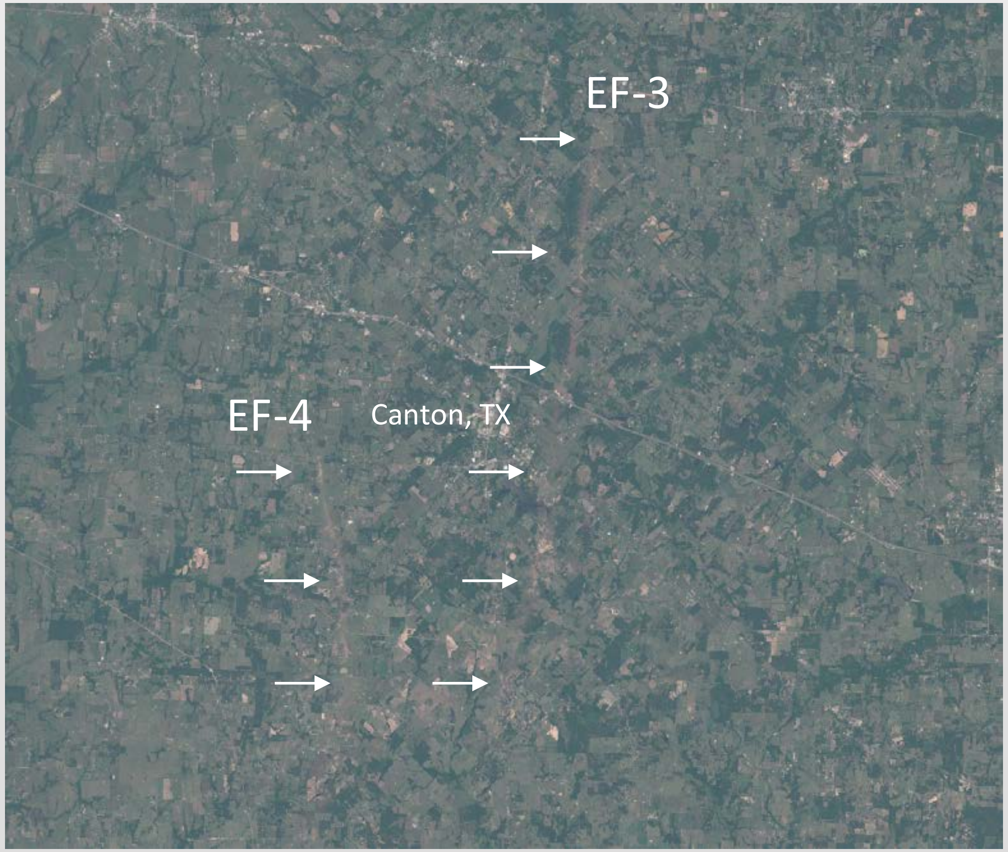
Tornado Track Detection

As with hail damage, tornadoes disrupt a path of vegetation that becomes apparent in true and false color compositing or other change-based analysis.

Two tornado tracks are apparent from Sentinel 2A observations on May 7, 2017 for tornadoes near Canton, TX.

Visual identification of tracks in single-day, cloud-free imagery can be helpful for finding tornadoes that may have been missed, locating tracks where they are otherwise inaccessible, or to provide an aerial view of the extent of impacts.



Sentinel 2A true color image of tornado tracks near Canton, TX on May 7, 2017.

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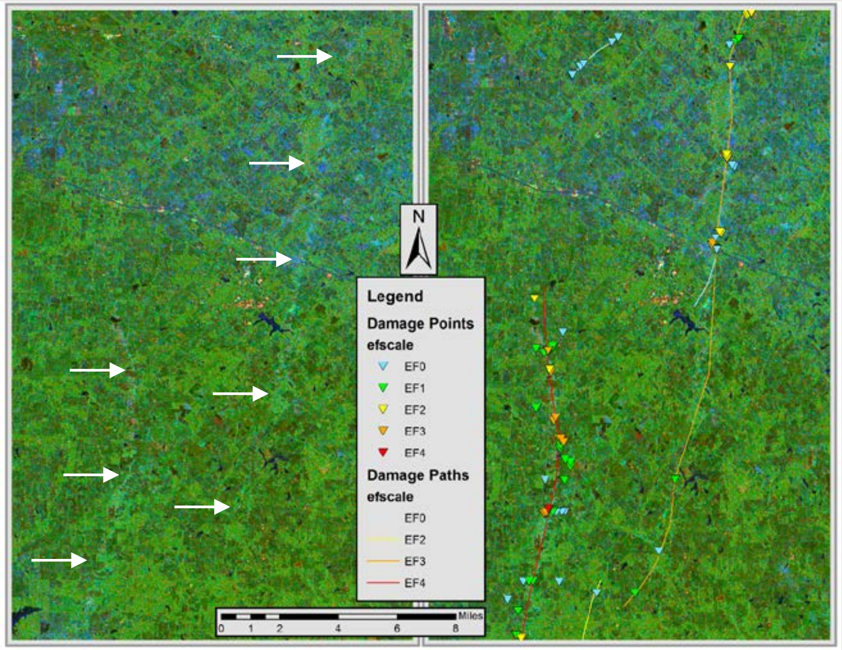
Tornado Track Detection

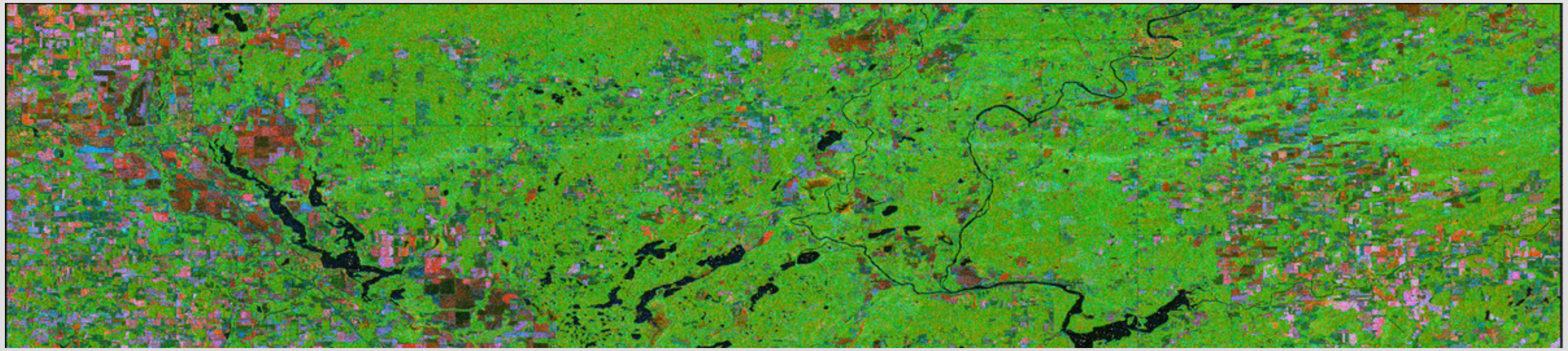
As with hail damage, tornadoes disrupt a path of vegetation that becomes apparent in false color compositing and other change-based analysis.

Here, false color composites *focused on change detection*, look at differences in VH-polarization returns pre- and post-storm to visually identify tracks.

Information is shared with National Weather Service meteorologists to help inform their tornado damage survey process.



Sentinel 1A Change RGB:
Canton, Texas – EF-4 tornado



Sentinel 1A Change RGB: Clear Lake, Wisconsin -- EF-2 tornado

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Summary / Conclusions

- Optical and synthetic aperture radar remote sensing provide numerous application opportunities to map the impacts of disasters
  - Flooding, severe weather, tropical cyclones, and other impacts have been used by U.S. partners including FEMA, the National Guard, and the National Weather Service
- Efforts will continue to evolve towards automated change detection and anomaly-based products that provide detailed mapping in addition to visual interpretation
- Collaborations with ESA on access to data and products is extremely helpful, and we look forward to working with others on new product concepts, development, and training