Developing Disaster Response Applications with future NISAR Capabilities

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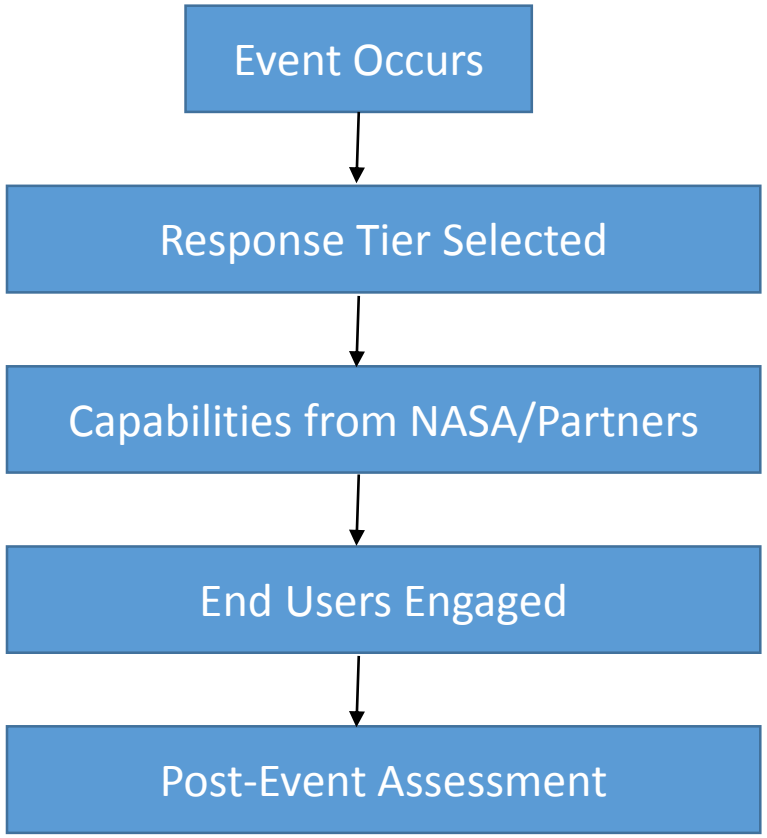
NASA Earth Science Disaster Response Team

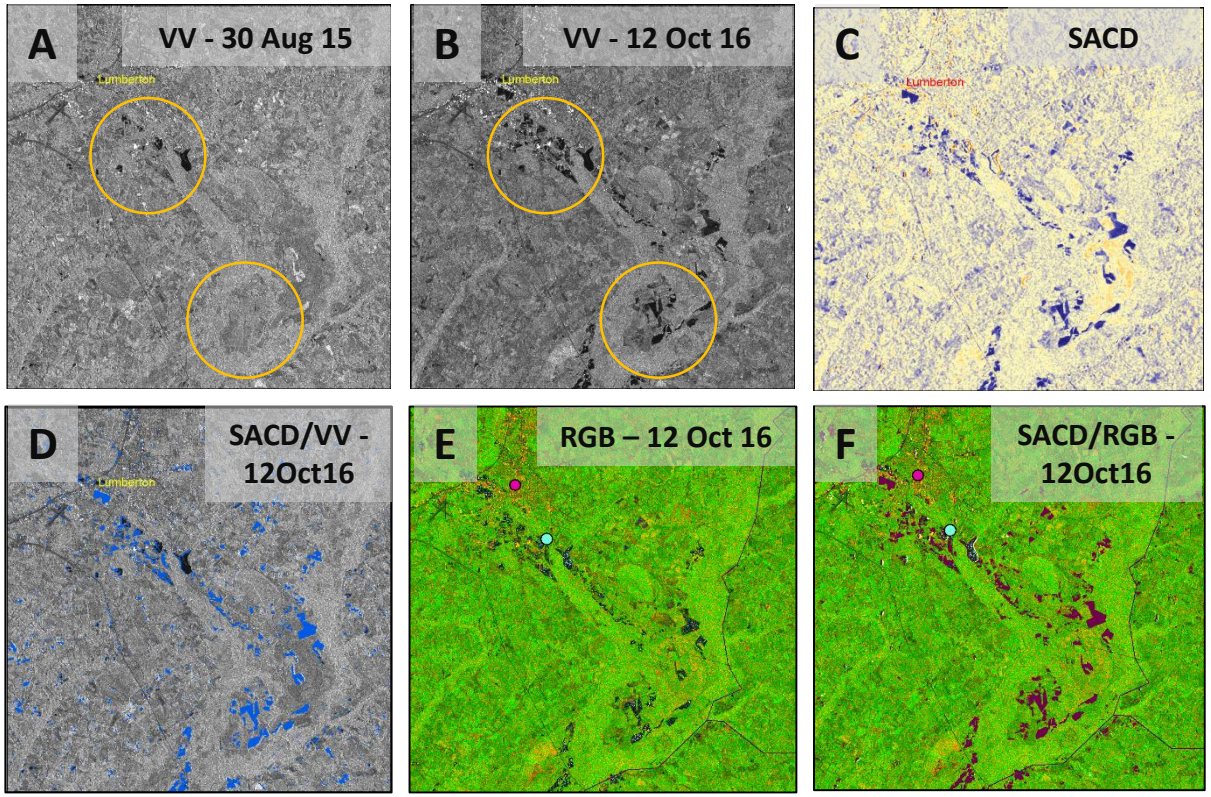
- NASA's Earth Science Division has established a Disaster Response Program led by Dr. David Green, Program Manager for the Applied Sciences: Disasters Program
- When a disaster event occurs, a team comprised of multiple NASA Centers and other partners collaborate on products to assist with response activities.
  - For example, mapping of the disaster impact, working to provide training on use of NASA products, etc.
- Several disaster events throughout the year with multiple domestic and international collaborators.



Collaborations with the Alaska Satellite Facility

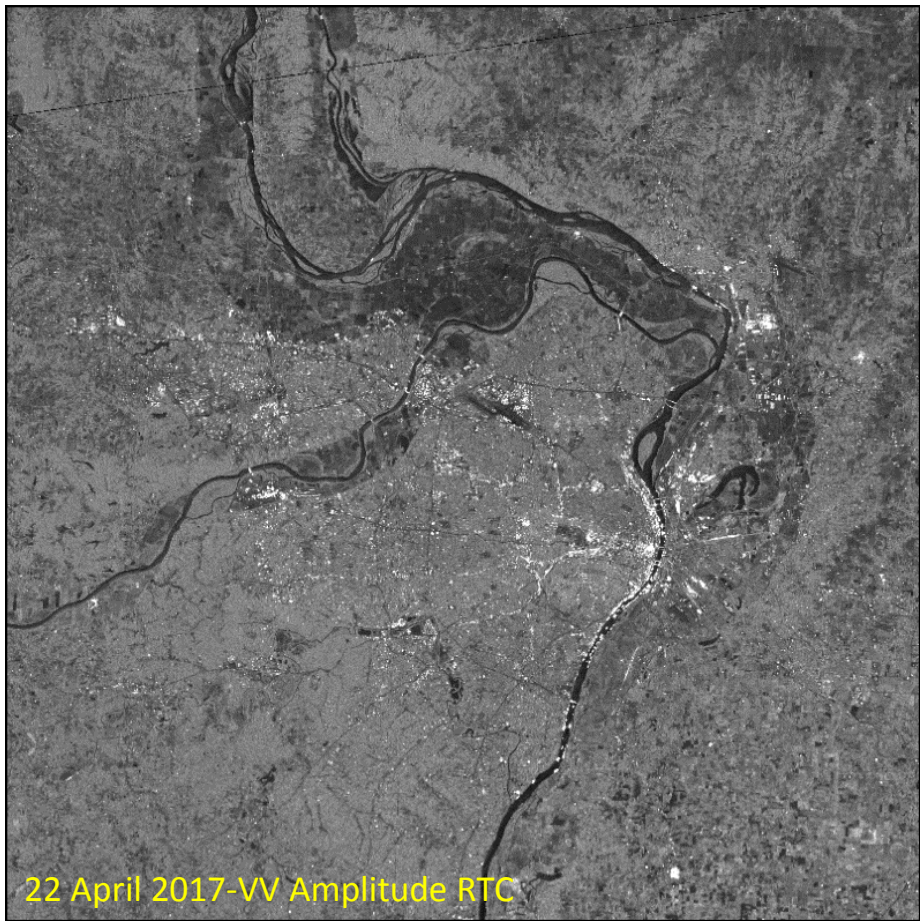
- Team members have been collaborating with the Alaska Satellite Facility to develop SAR expertise in preparation for the NISAR mission.
- Team members from ASF serve on the NISAR Science Team and Applications Team, and MSFC team members hope to be included in future efforts.
- Our staff have traveled to Alaska to work with ASF on developing products of interest and benefit to end users with primary focus on disasters.
- Goals:
  - Build knowledge of SAR and new product concepts
  - Prepare for science and applications available from NISAR

Hurricane Matthew



Hurricane Matthew case study. A) VV-polarization RTC image from 30 Aug 15. B) VV-polarization RTC image from 12 Oct 16. C) Simple Algorithm Change Detection (SACD) output. D) Threshold applied to SACD (C) and overlaid on post VV-image (Blue). E) RGB from 12 Oct 16. F) RGB with change detection overlaid.

Missouri Floods of Spring 2017



- In late April 2017, portions of the Midwest received heavy rainfall over the course of multiple days.
- This caused the rivers to rapidly swell and begin flooding.
- Several federal agencies responded to the river flooding, including the Federal Emergency Management Agency (FEMA).
- These Sentinel 1 products were generated by HyP3 and provided by the Alaska Satellite Facility and NASA Marshall Space Flight Center to derive change detection and flood mapping for FEMA analysis.

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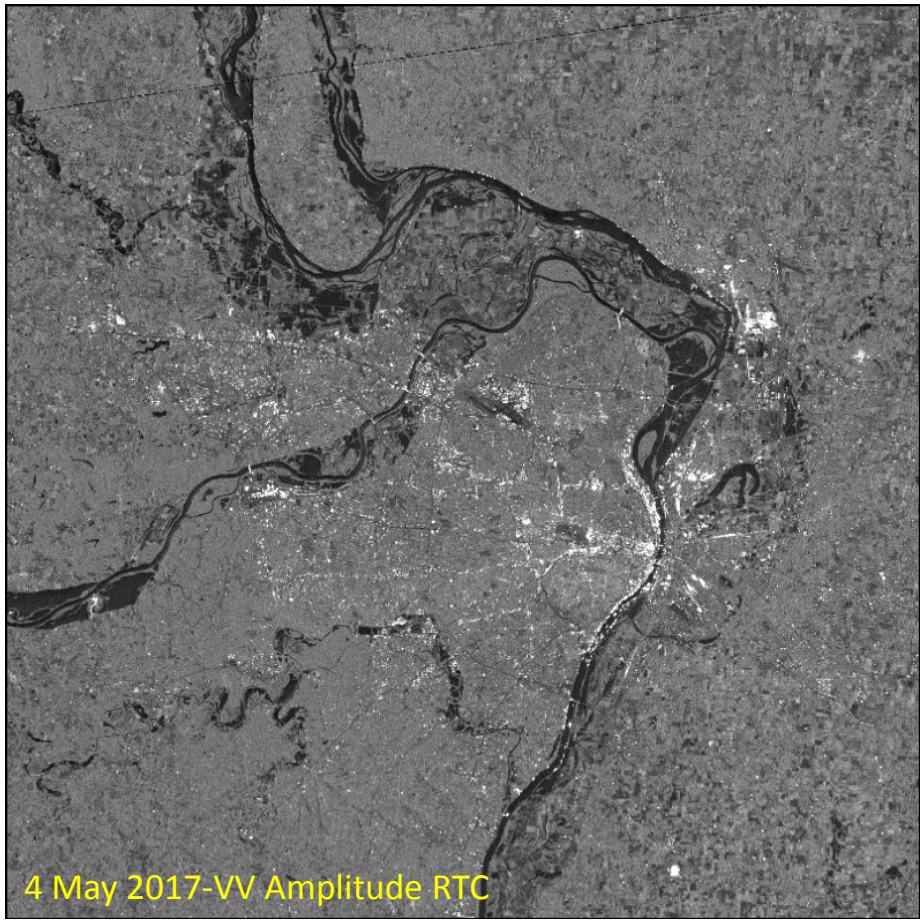

- In this post event scene, numerous areas have darkened due to heavy rainfall and flooding.
- Urban structure of St. Louis metro area is also evident with areas of much brighter and consistent backscatter.
- Darkened areas represent change from the previous scene which is used in a simple threshold-based change detection to help identify water.
- Resulting water areas can be used by FEMA to map impacts.

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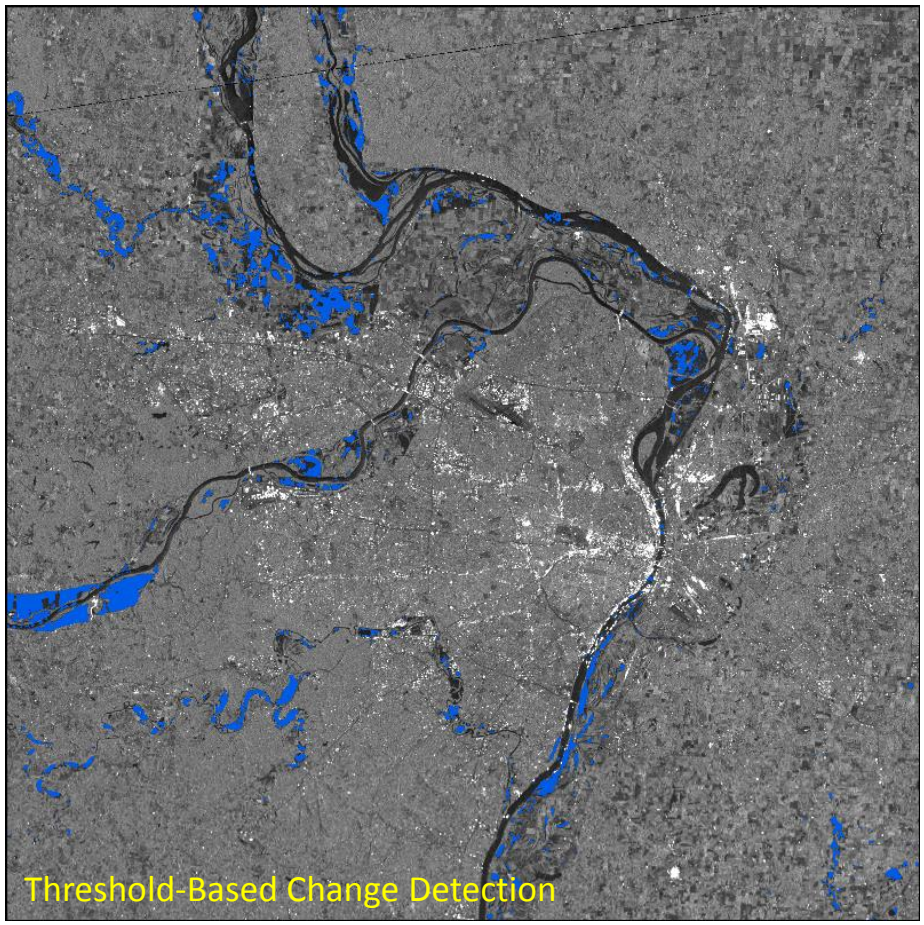

- The final image here with blue overlay outlines areas of change likely associated with flooding.
- SPoRT is then able to provide this information to FEMA along with discussion on appropriate use and caveats, in conjunction with technical discussions and information sharing with ASF.
- HyP3 provides valuable pre-processing and product generation that allows for reduced effort, quick response, and more consistency of product generation that facilitates training and use of outputs.

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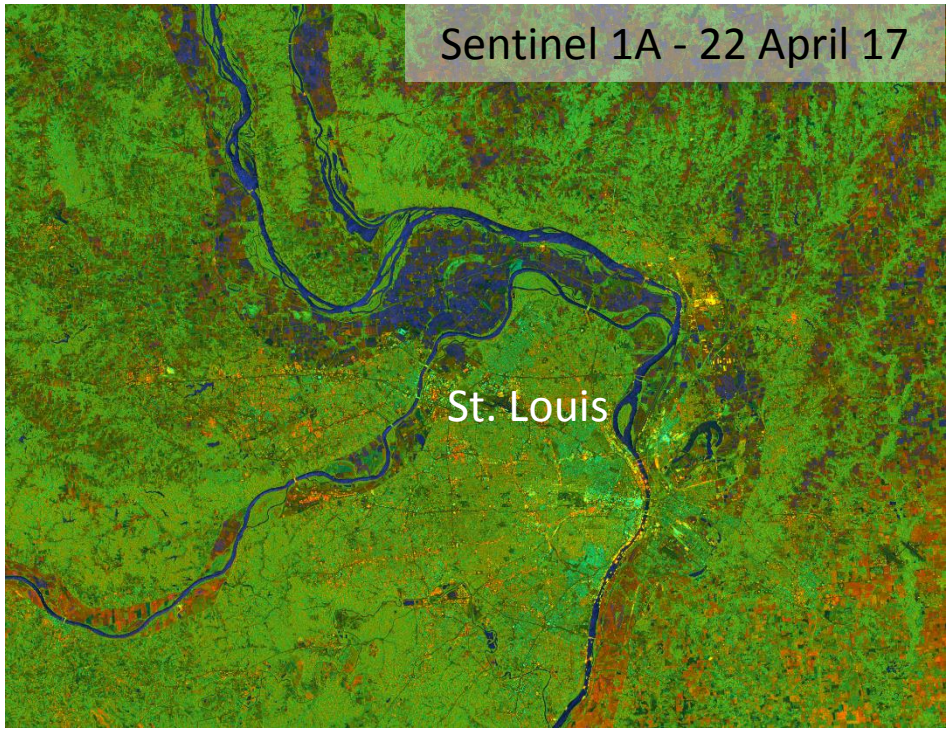
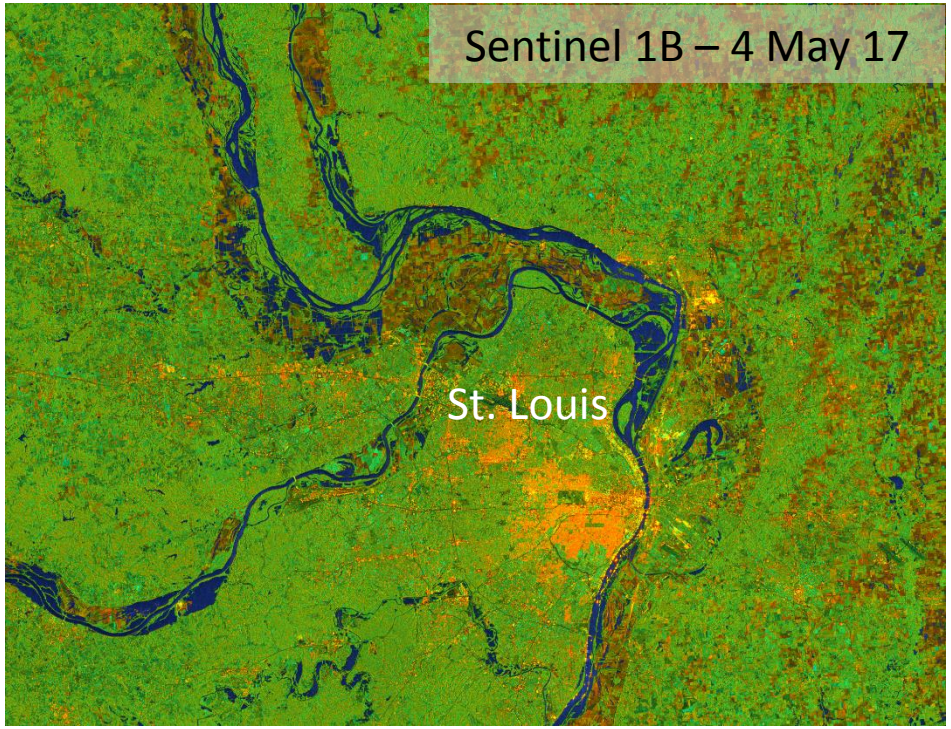


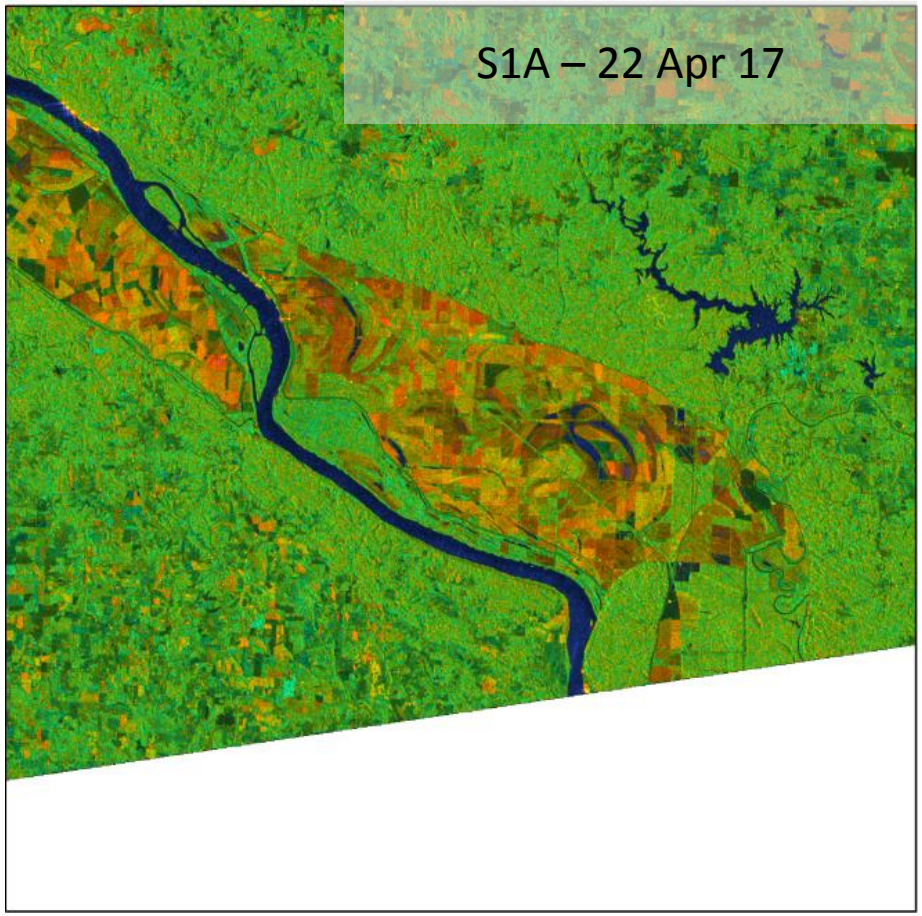
- SPoRT has explored the use of false color composites of VIS/NIR/IR data in collaboration with the National Weather Service and preparations for GOES-16
- ASF has developed false color composites from Sentinel 1A that help with visual identification of various features
- Changes in false color composites could also help to highlight changes in the surface – and separately, false color composites can be derived to focus on land surface change
- Pre-event scene here captures water extent and vegetation around St. Louis

Missouri Floods of Spring 2017



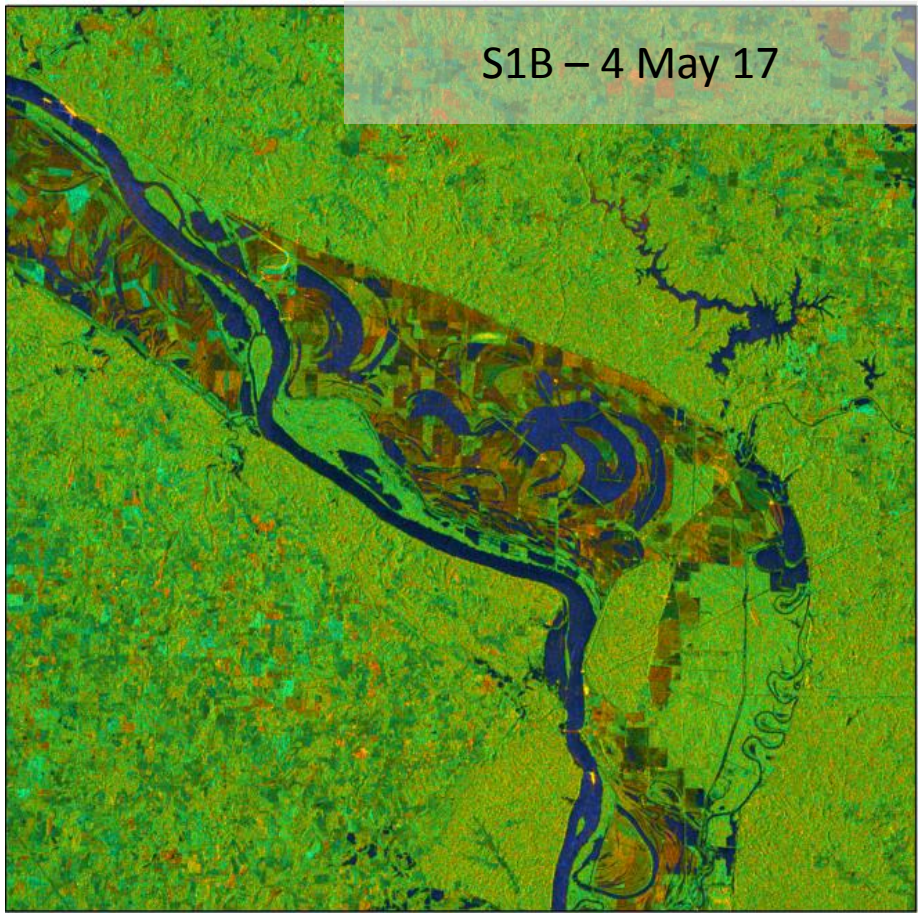
- With increase in flooding and water extent, change in false color composite coloration helps to visually confirm where flooding of larger-scale floodplains and tributaries have occurred
- Other changes apparent, including appearance of downtown St. Louis and surrounding vegetation, potentially due to differences in viewing angle, time of day, and other factors
- In general, many of the flooded areas can be seen visually that result in darker shades and blues

Missouri Floods of Spring 2017



- To better understand these false color products and interpretation, and eventually assist with training, we compare to change detection products and VIS/NIR interpretation for similar time periods

Missouri Floods of Spring 2017

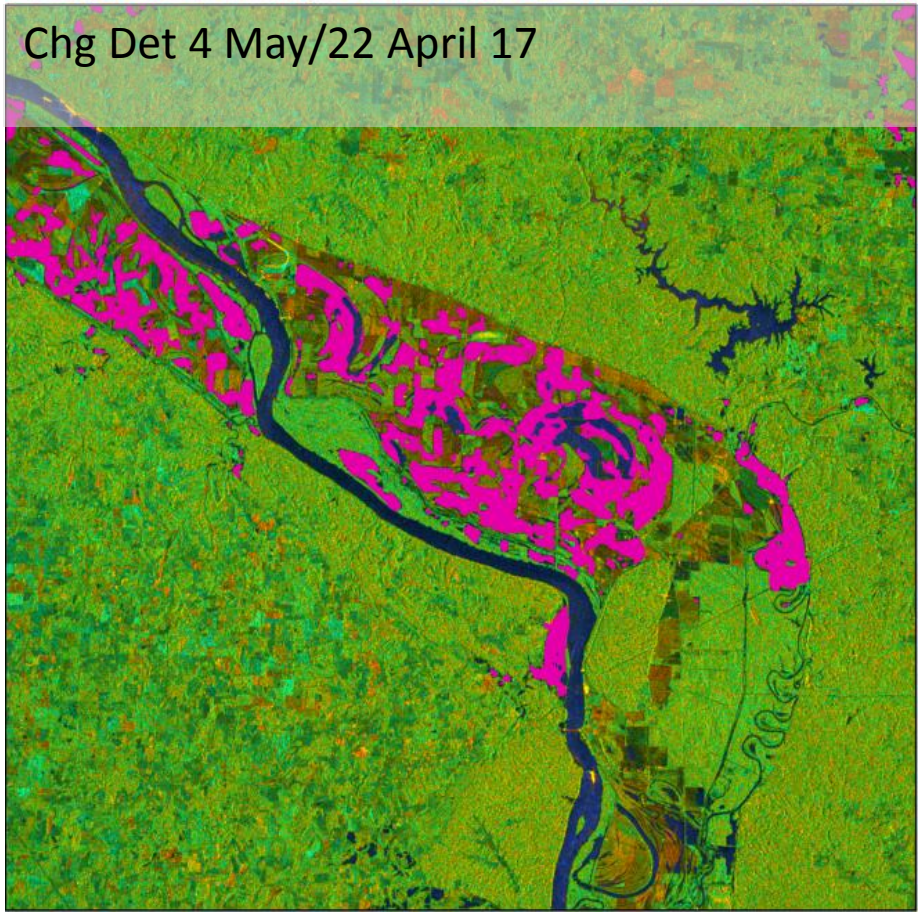


- Here, expanded coverage of water and darkened fields (soil moisture) are shown in a curve of the Mississippi River south of St. Louis

Missouri Floods of Spring 2017

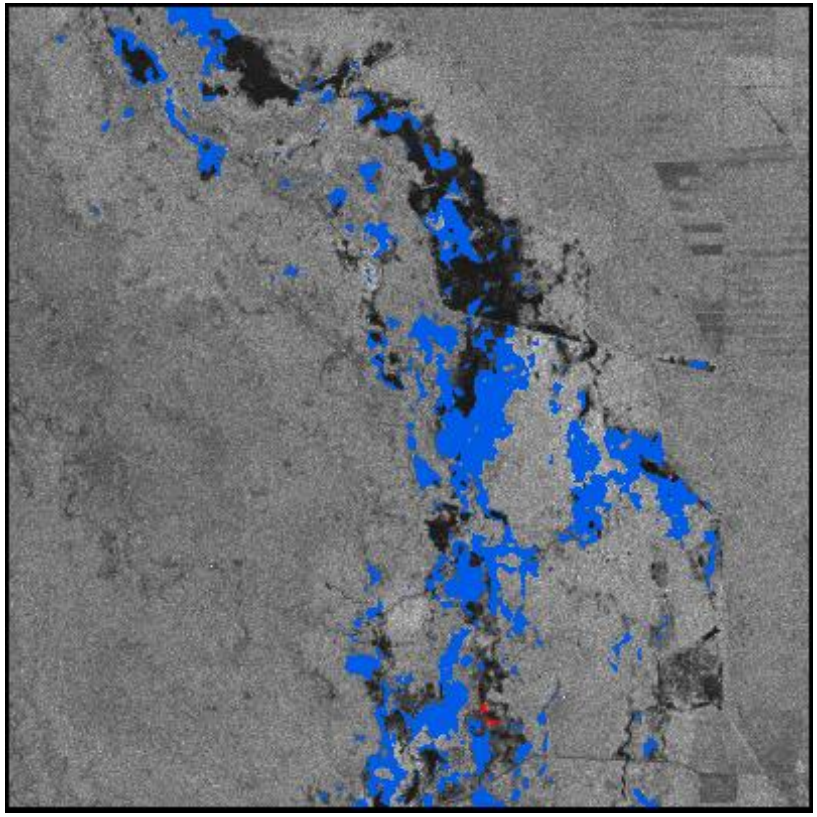
- Water extent, saturated fields, and flooding corresponds well to the visual interpretation of true color imagery from the SPOT 6 sensor on the following day, helping to confirm interpretation and provide a future training example

Missouri Floods of Spring 2017



- Change detection (differencing and thresholding) highlights many areas of flood water atop the post-flood image.
- Some areas that have a persistent appearance of water in both scenes capture “normal” conditions and are not flagged in the change detection approach

International Support

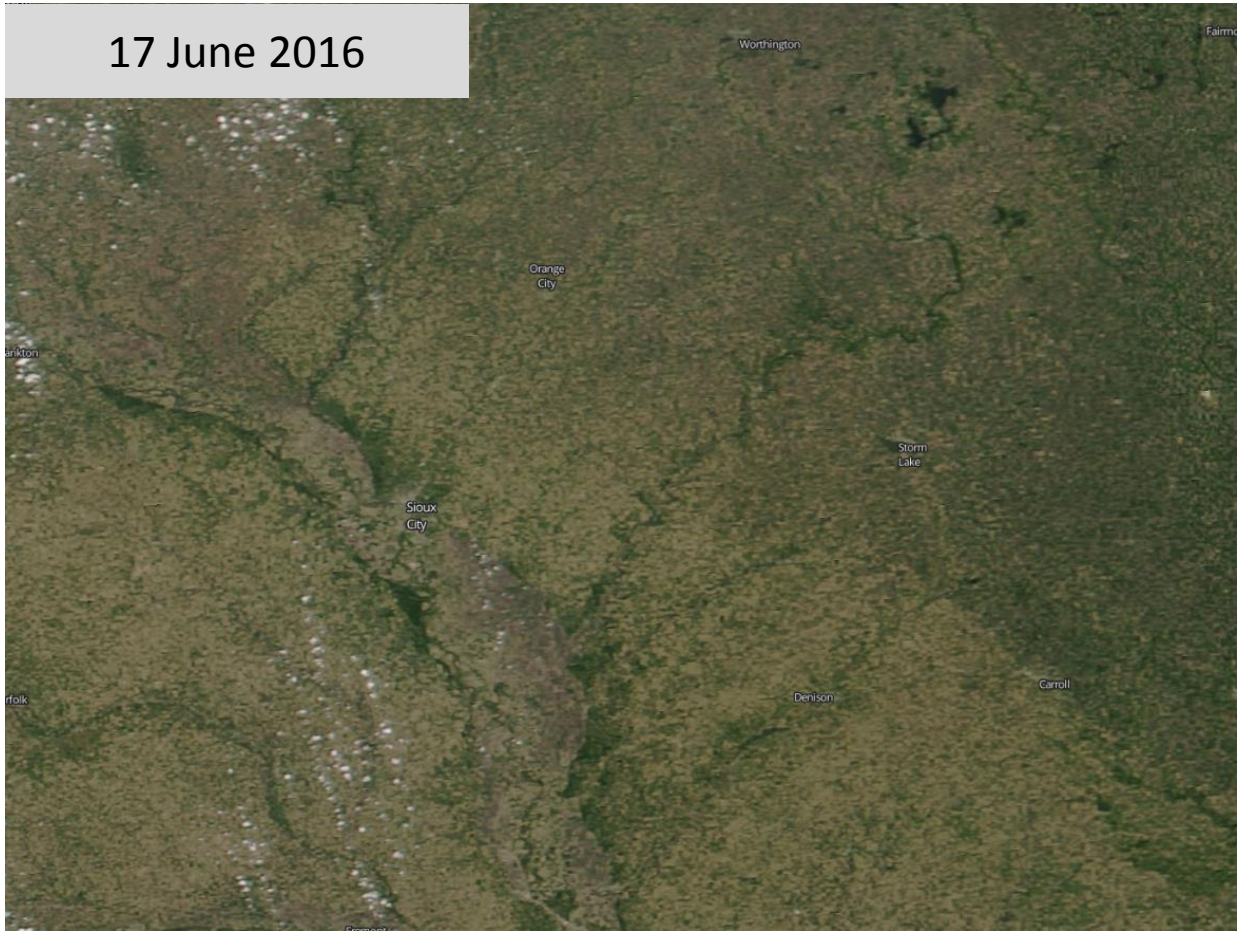


- In support of the NASA Earth Science Disasters Program and response activities, MSFC team members have worked with ASF/HyP3 to request RTC products, change detection, and other tools.
- Here, flooding in Argentina is mapped in shades of blue (change detection / threshold)

Severe Weather Applications

- Severe thunderstorms, including damaging straight-line winds in combination with hail can cause widespread damage to vegetation observable from optical remote sensing and SAR
- Similarly, tornadoes that cause long damage tracks and disruptions in urban settings can also be detected through changes in backscatter
- Collaborations between SPoRT and NOAA/NWS have transitioned imagery products to support damage assessments, including SAR applications

Hail Damage in Iowa



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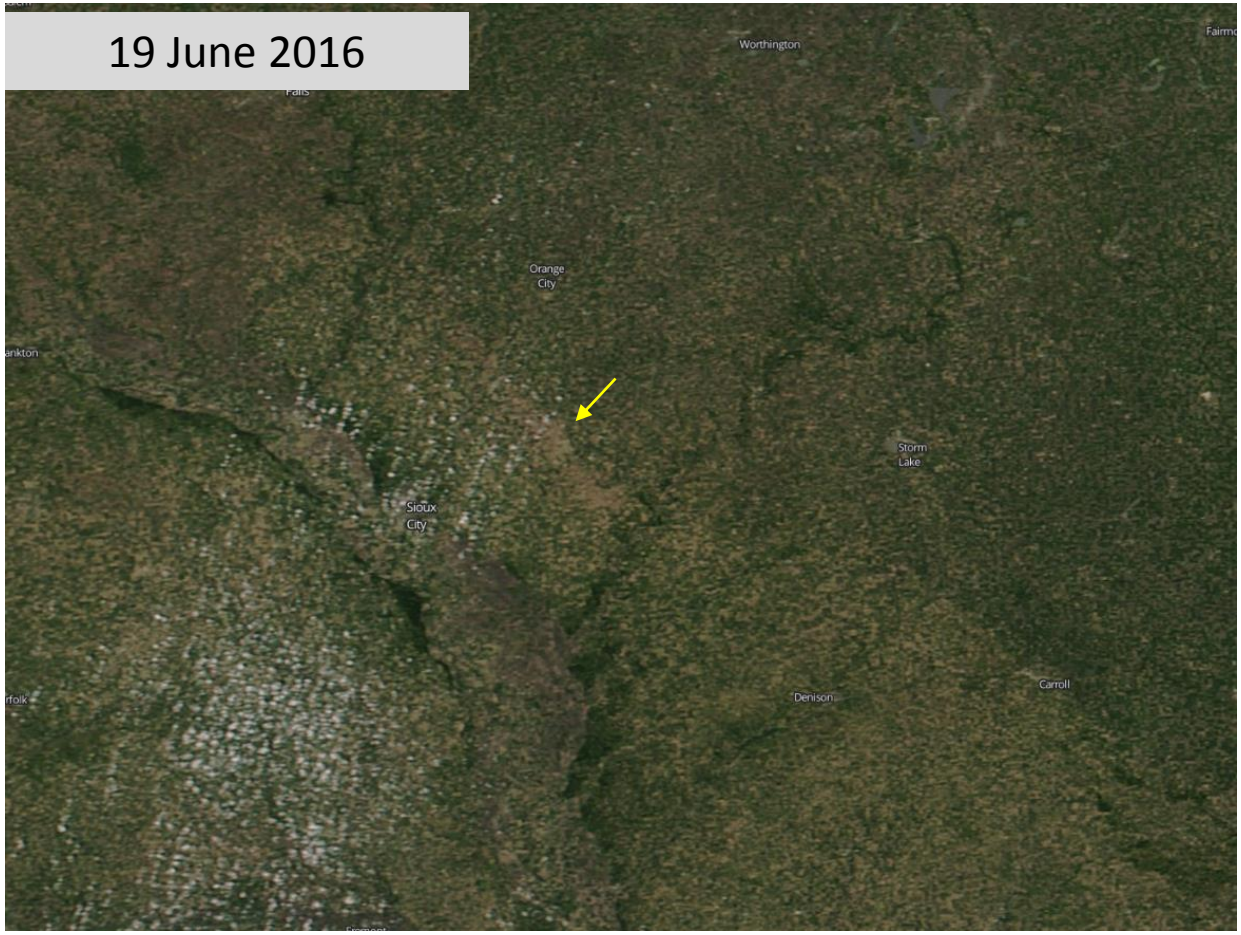

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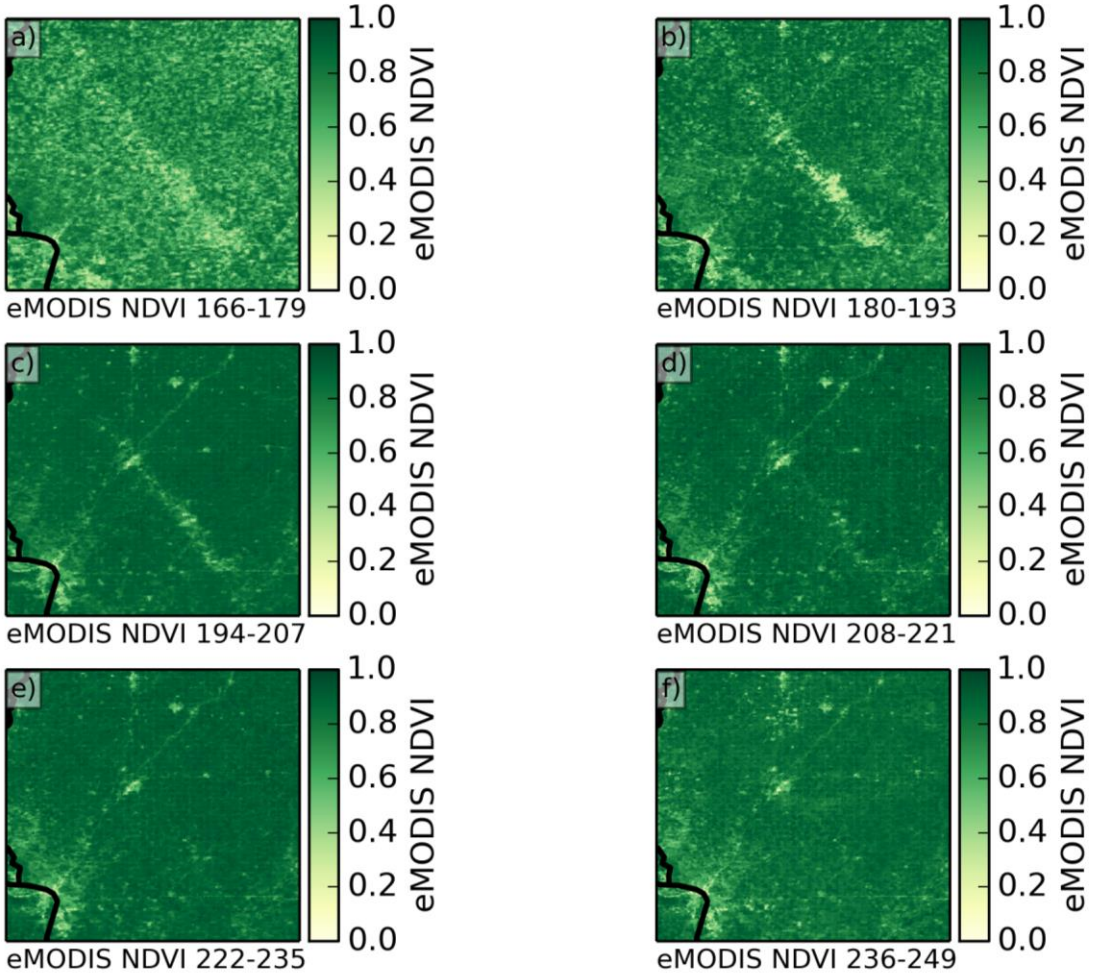

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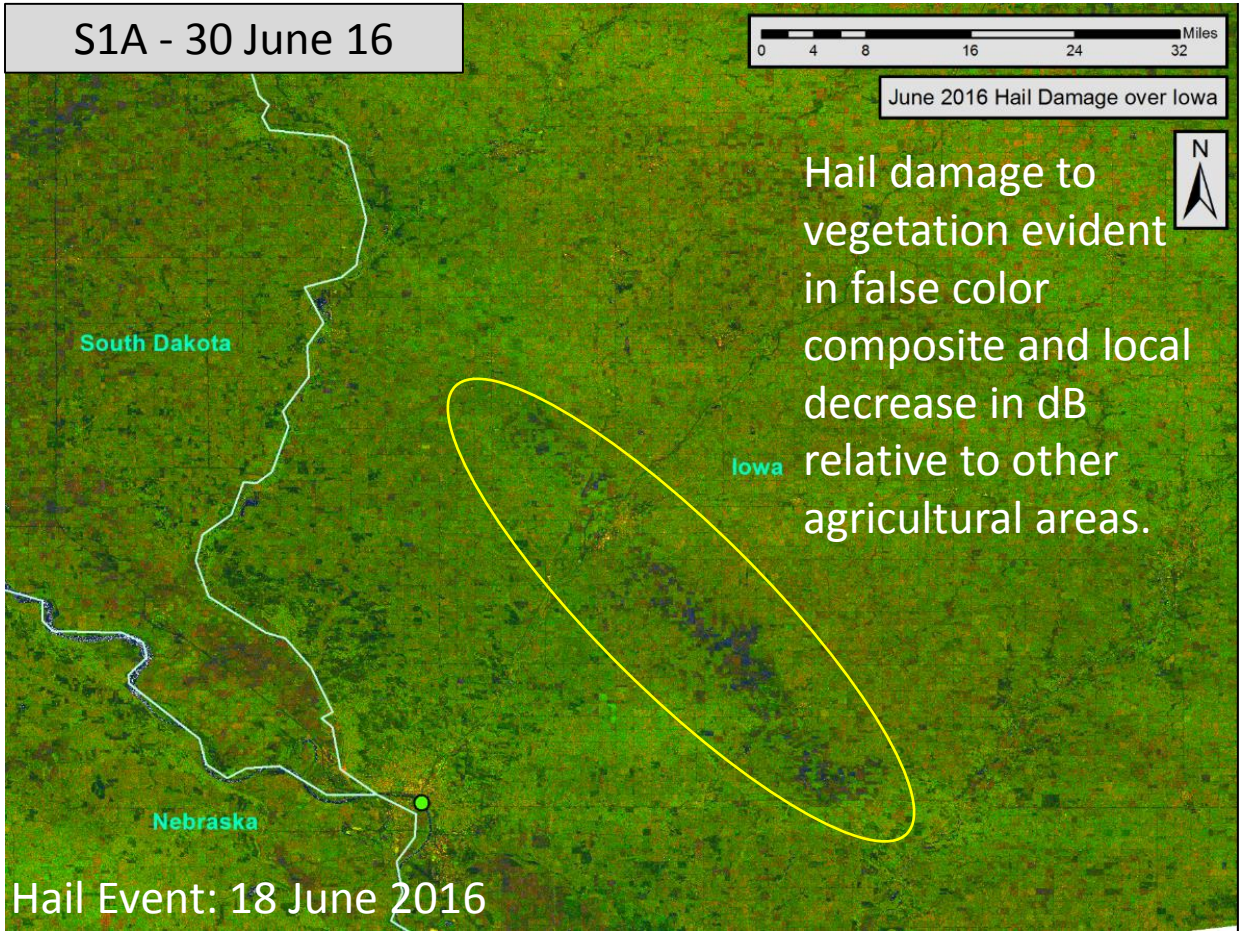

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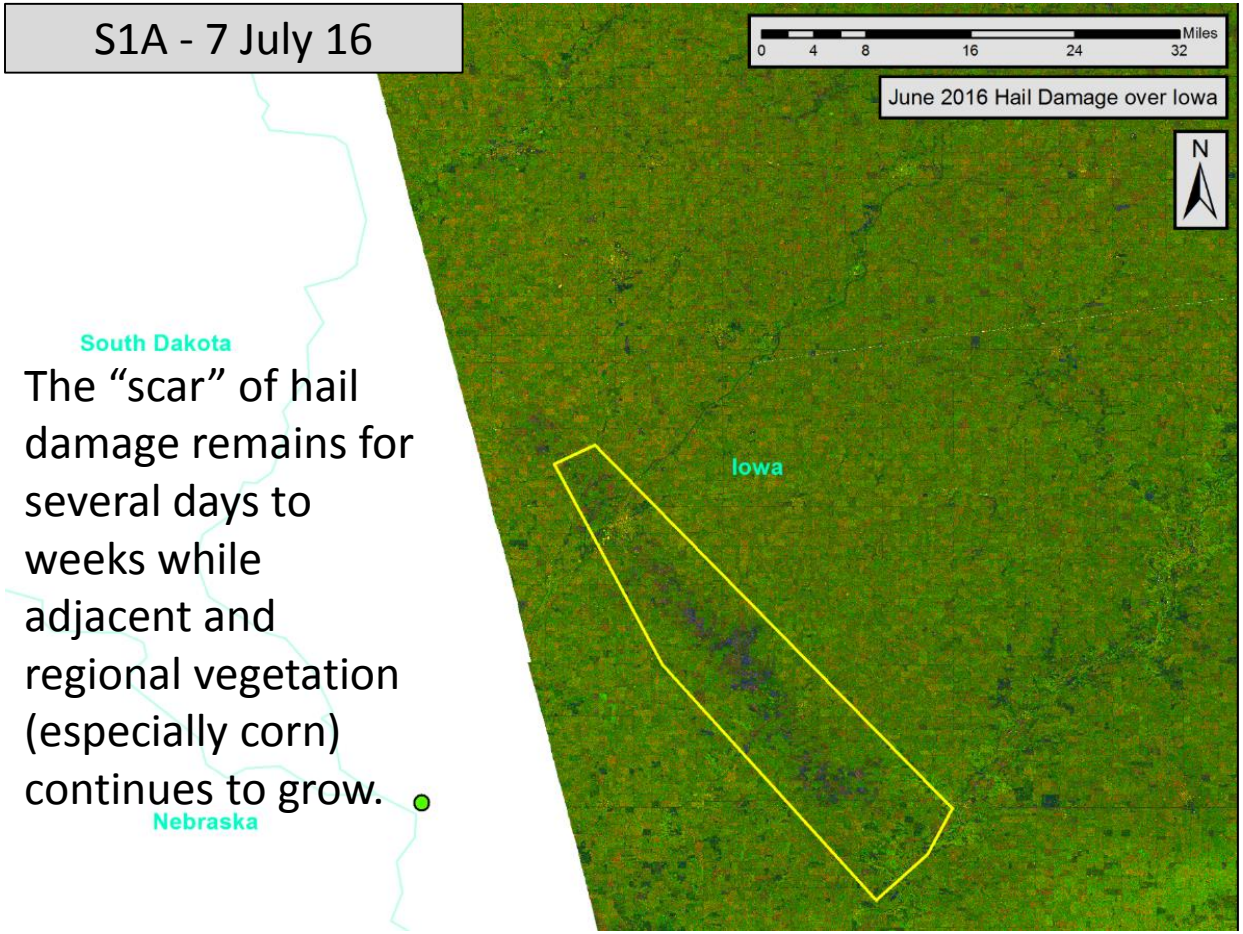
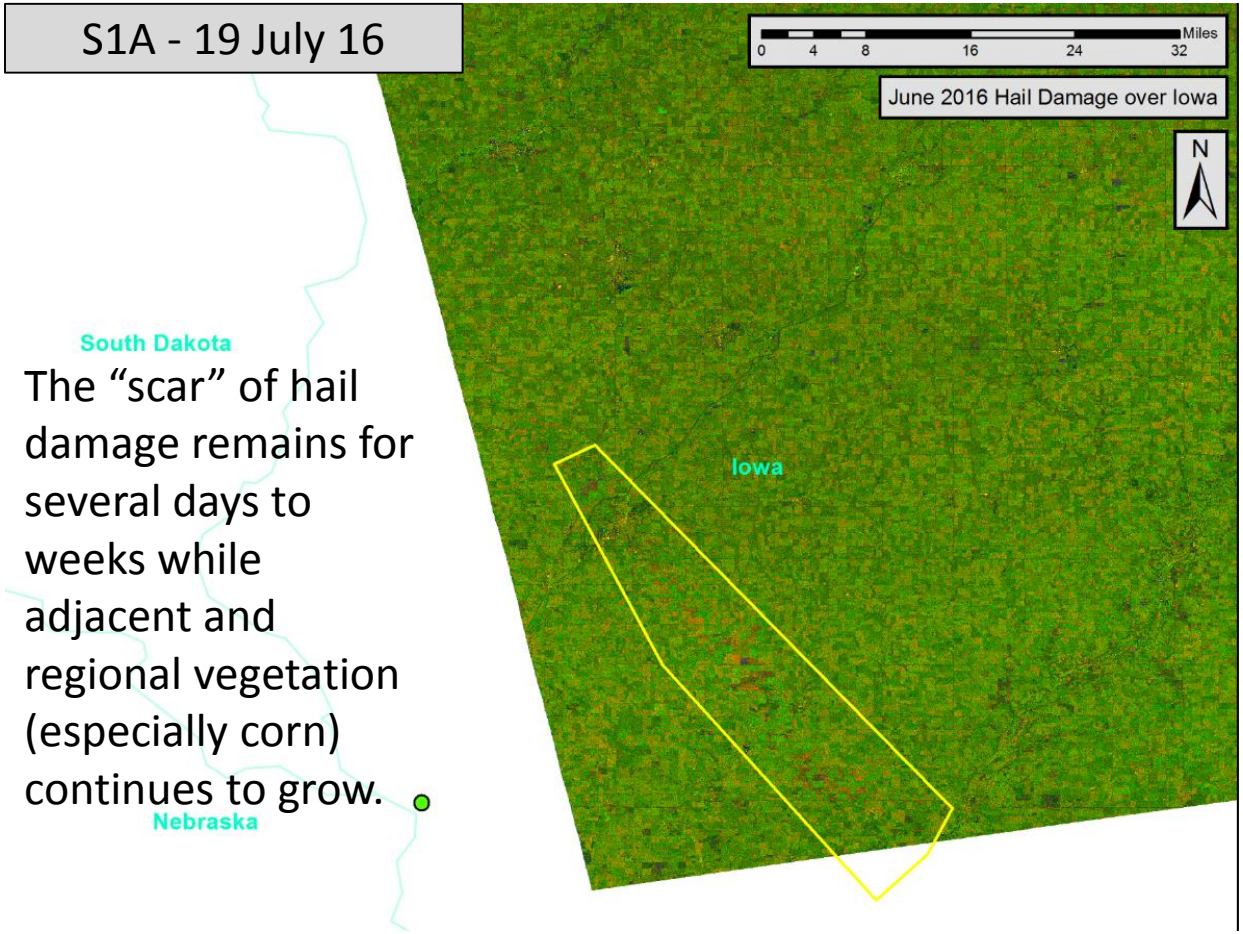


The "scar" of hail damage remains for several days to weeks while adjacent and regional vegetation (especially corn) continues to grow.

Hail Damage in Iowa



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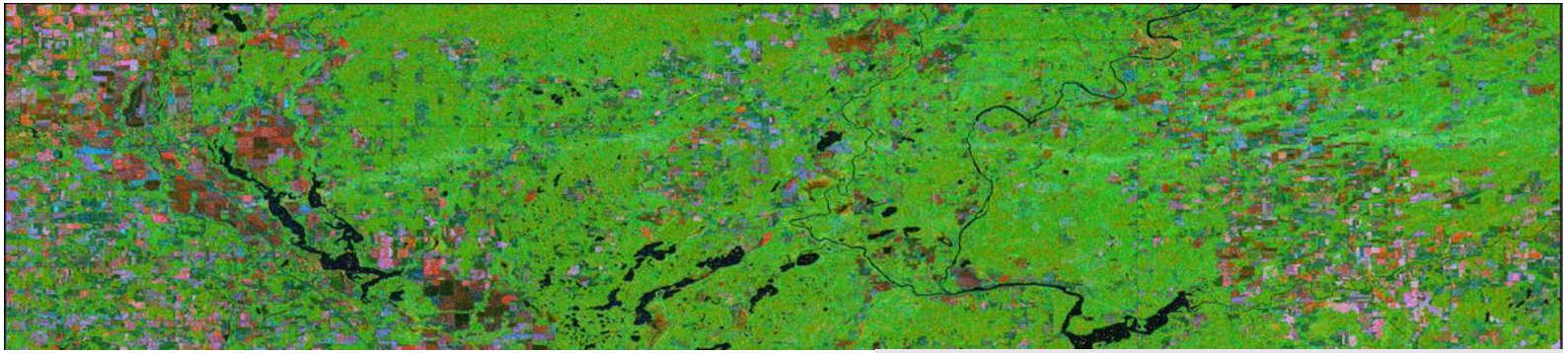
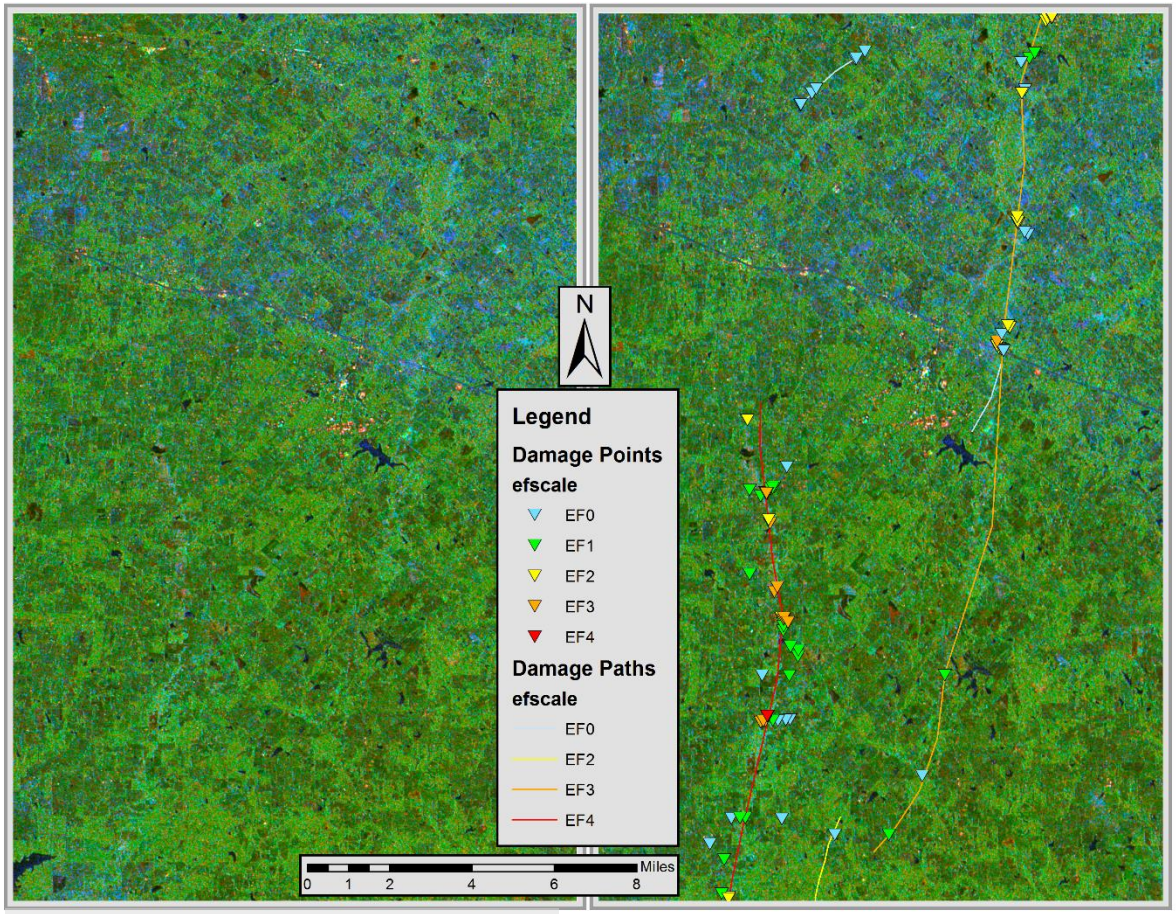
Tornado Damage



Clear Lake, Wisconsin -- EF-2 tornado

- Qualitative RGB allows the end-user to analyze the image and compare to known damage points that are acquired during their ground survey
- Also exploring automated extraction of changed areas similar to hail study

Tornado Damage



Canton, Texas – EF-4 Tornado

- Testing of a change detection RGB, taking advantage of the difference between the VH-polarizations of a before and after image to help identify tornado tracks in vegetated areas.
- Requires some additional analysis to help confirm physical interpretation and use by forecasters to help identify track details.

Future Work

- Build SAR expertise in collaboration with the Alaska Satellite Facility, and assist in product development to build capabilities prior to NISAR launch
- Work with disaster response organizations such as FEMA, U.S. National Guard, and others to get input and feedback on SAR-derived products.
- Align ourselves to collaborate with the NASA NISAR Science Teams and Applications Teams to help end users successfully apply NISAR data to their objectives.