# NASA Earth Science Activities Supporting Domestic U.S. Response and Preparedness to Meteorological Disasters

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# About

Promotes the use of Earth observations to improve prediction of, preparation for, response to and recovery from natural and technological disasters

Disaster applications and applied research on natural hazards support emergency preparedness leaders in developing mitigation approaches, such as early warning systems, and providing information and maps to disaster response and recovery teams.

Highlights of 2018

For more information please visit: https://disasters.nasa.gov/ to read about the program.

To view near real time (NRT) products as well as those developed for event-specific support, visit: https://maps.disasters.nasa.gov/

# Hurricane Florence

GLOBAL PRECIPITATION MEASUREMENT MISSION, COPERNICUS SENTINEL 1 A/B, LANDSAT 8, NASA BLACK MARBLE HD IMAGERY, MODIS FLOOD, GLOBAL FLOOD MONITORING SYSTEM
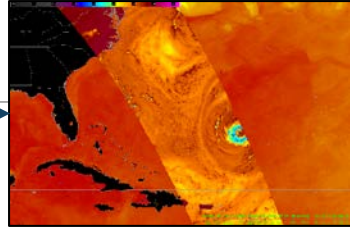
# Disaster Response and Engagement: Hurricane Florence



*Int'l Space Station*

Team coordination began prior to **9/11** and continued daily throughout the event

Partners/Stakeholders engaged prior to and throughout storm's impact: FEMA, NGB, NOAA, USFS, USGS, US Army Geospatial Center, Department of Interior
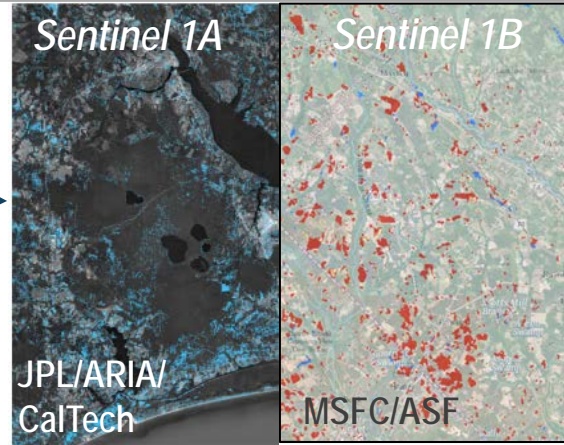
*Monitoring the Storm:* GPM data provided to support operational forecasting (SPoRT Center, via R&A)

**Andrew Molthan (MSFC) embedded in FEMA Operations 9/13-9/20**

*Flood Mapping:*
Generate flood and damage proxy maps via ESA & International Charter with SAR and optical imaging
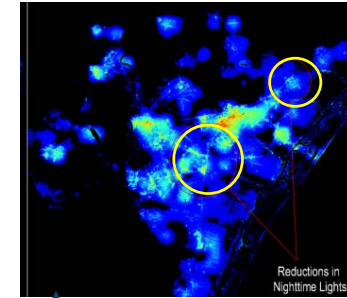
*Sentinel 1A*    *Sentinel 1B*

JPL/ARIA/CalTech    MSFC/ASF

*NASA Black Marble HD:*

Black Marble HD: Captures lights missing in coastal Wilmington, NC

Decreased illumination compared to pre-event composite

**Similar activities supported during Hurricane Michael from October 9-17**

9/11    9/12    9/13    9/14    9/15    9/16    9/17    9/18    9/20

*Global Flood Monitoring System*

Provided forecasts and near real-time estimates extent of flood inundation

Recent NASA Products: Hurricane Florence

NASA Data/Product portal available via Esri Services
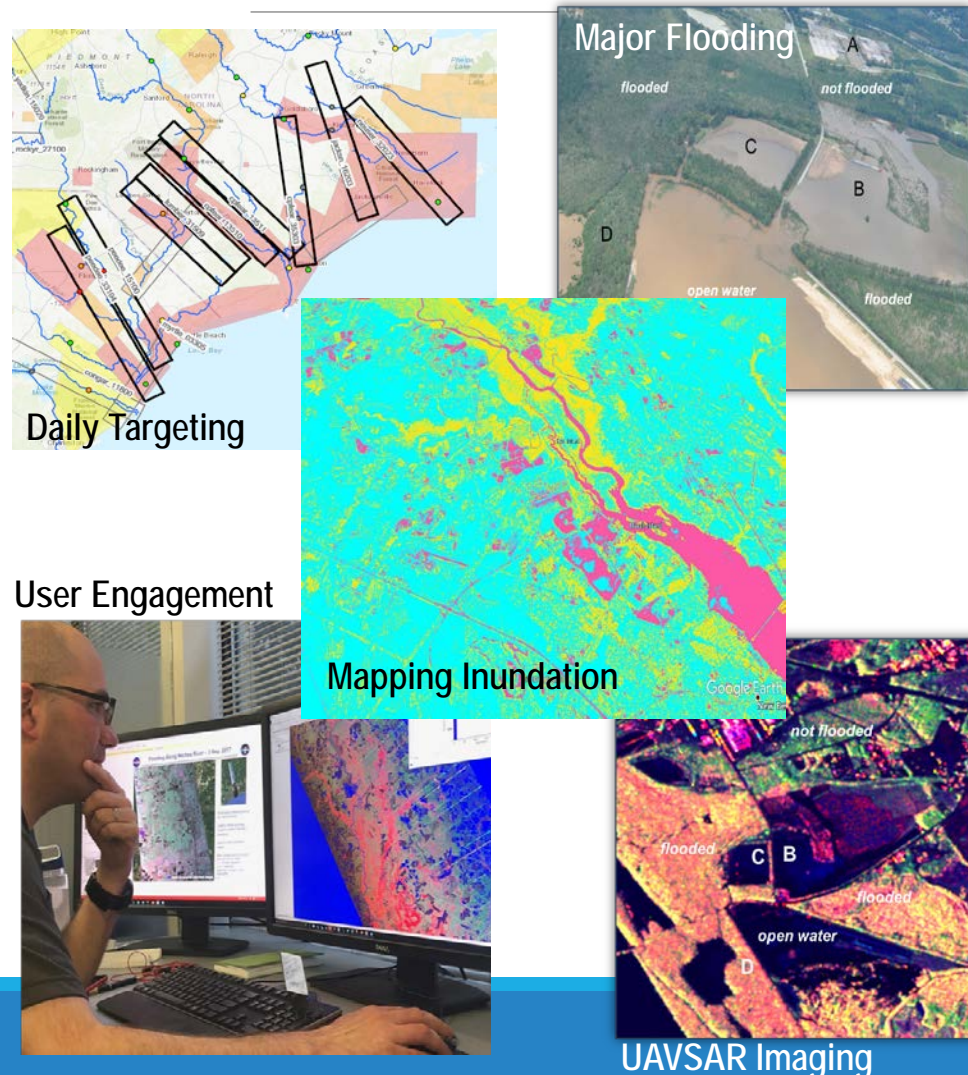
not flooded
flooded
open water
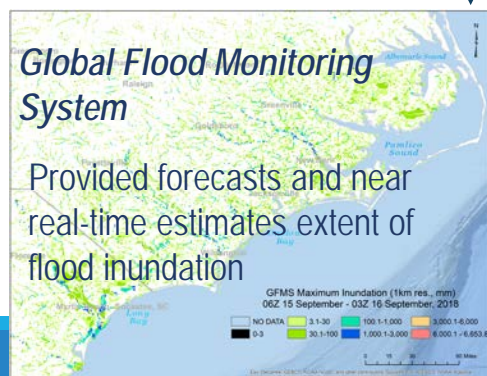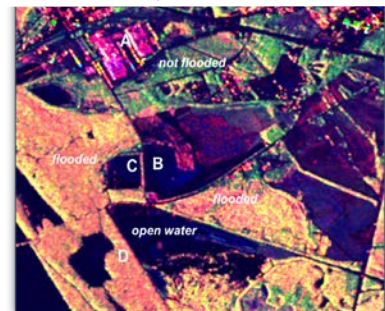
UAVSAR in Gainesville, FL September 17-24

*UAVSAR Flights Support Research and Response*
Mission Assigned from FEMA for immediate flood mapping

*Mapping Floods as Skies Clear:*
MODIS & Landsat-derived flood maps in affected areas

*MODIS Flood Mapping*

*L8/OLI*

https://maps.disasters.nasa.gov

# UAVSAR


Daily Targeting


Major Flooding


Mapping Inundation


User Engagement


UAVSAR Imaging

FEMA mission assignment of the G-III/UAVSAR for repeated collections of L-Band SAR in flooded regions;

- Polarimetric color composite images provided to show flood extent including under tree canopies as well as areas covered by other vegetation

Team efforts of NASA and FEMA targeted daily UAVSAR collections where significant river flooding was ongoing or expected in areas of intensive risk, to support both response and further study

- Flew 6 days and collected 45 flight lines

Rapidly available imagery provided to FEMA following each flight, to the USFS, and to the community via NASA Disasters Portal and partners at HDDS.

Team engagements supported through on-site support:

- *"NASA provided a visiting scientist (Andrew Molthan/MSFC) who helped process and integrate UAVSAR data into our existing, time-sensitive flood detection and structural assessment workflows." – FEMA, Subcommittee on Disaster Reduction, 10/4*

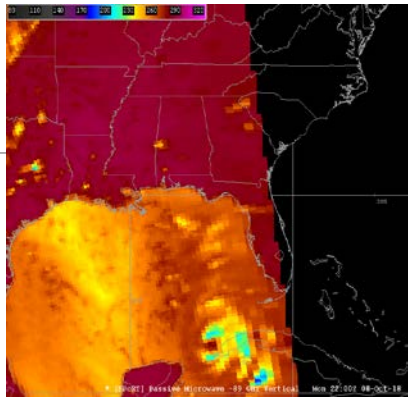Image Credit: Andrew Molthan, October 2018, used with permission

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# Hurricane Michael

GLOBAL PRECIPITATION MEASUREMENT MISSION, COPERNICUS SENTINEL 1 A/B, LANDSAT 8, NASA BLACK MARBLE HD IMAGERY, MODIS FLOOD, GLOBAL FLOOD MONITORING SYSTEM
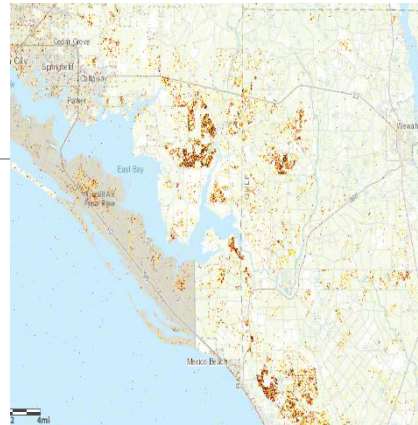
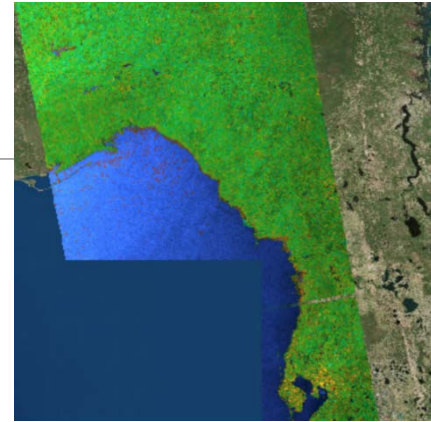# Response and Engagement Timeline: Hurricane Michael

NASA's Earth Science
## DISASTERS



***NASA Black Marble HD:***

Black Marble HD: Captures lights missing in Florida's Energy Sector
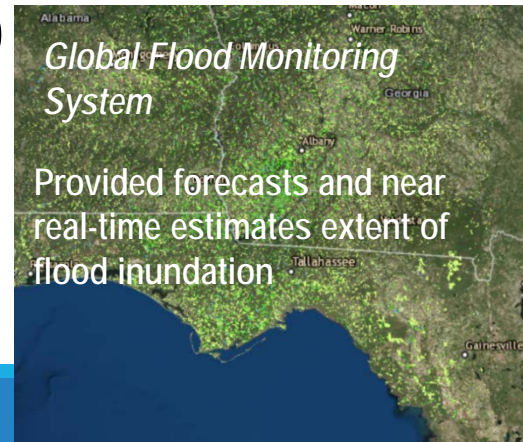
**Team coordination began prior to 10/10** and continued daily throughout the event

**Partners/Stakeholders** engaged prior to and throughout storm's impact: FEMA, NGB, NOAA, USFS, USGS, US Army Geospatial Center, Department of Interior

*Monitoring the Storm:* GPM data provided to support operational forecasting
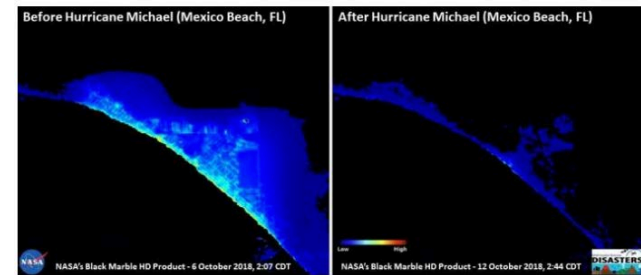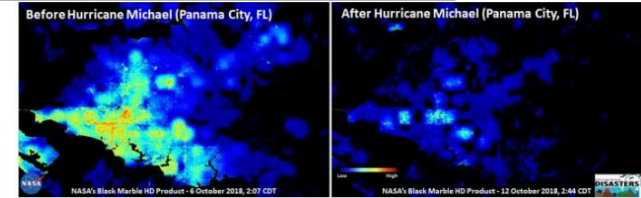
*Damage Mapping:* Damage proxy maps capture structure damage on immediate coastline

*Flood Mapping:* Identifying coastal and inland flooding from SAR imagery

**10/9**

**10/11**

**10/12**

**10/8**

**10/10**

**10/16**

NASA Data/Product portal available via Esri Services
http://maps.disasters.nasa.gov

NASA Products: Hurricane Michael
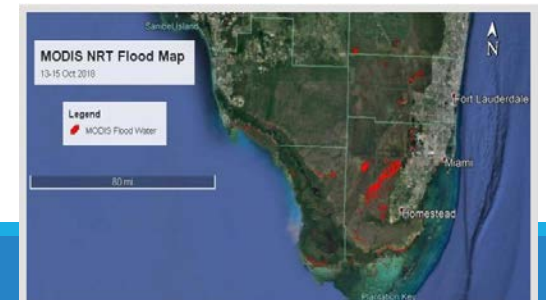
NASA Products for Hurricane...

*Global Flood Monitoring System*

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*Mapping Floods as Skies Clear:*
MODIS & Landsat-derived flood maps in affected regions

# National Level Exercise – 2019

DAY NIGHT BAND DATA FROM SUOMI-NPP VISIBLE INFRARED IMAGING RADIOMETER SUITE (VIIRS) INSTRUMENT

# Using the NASA Black Marble products to identify Power Outages

Day Night Band information from the Suomi NPP-VIIRS instrument has been used in multiple natural disasters in recent years to help identify where "lights" are missing

- A proxy for power outages

Caveats:

- How to account for the moon's influence on the scene?

- Presence of cloud cover that can mask lights from the sensor or cause a brightening

- How much light is missing? What is normal light?
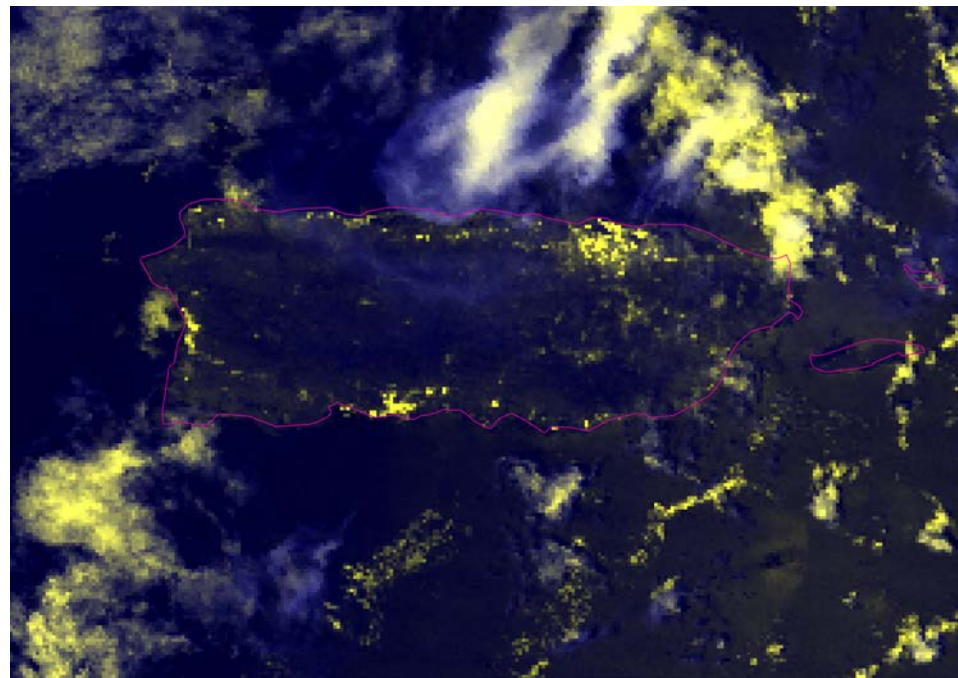


7 October 2017 Blackmarble generated DNB Radiance RGB (left) and the associated Percent of Normal product (lower) over Puerto Rico post Hurricane Maria

The DNB Radiance RGB was used to support the National Guard during the Maria recovery efforts.

This version of the Percent of Normal product was demonstrated/tested during the same period.
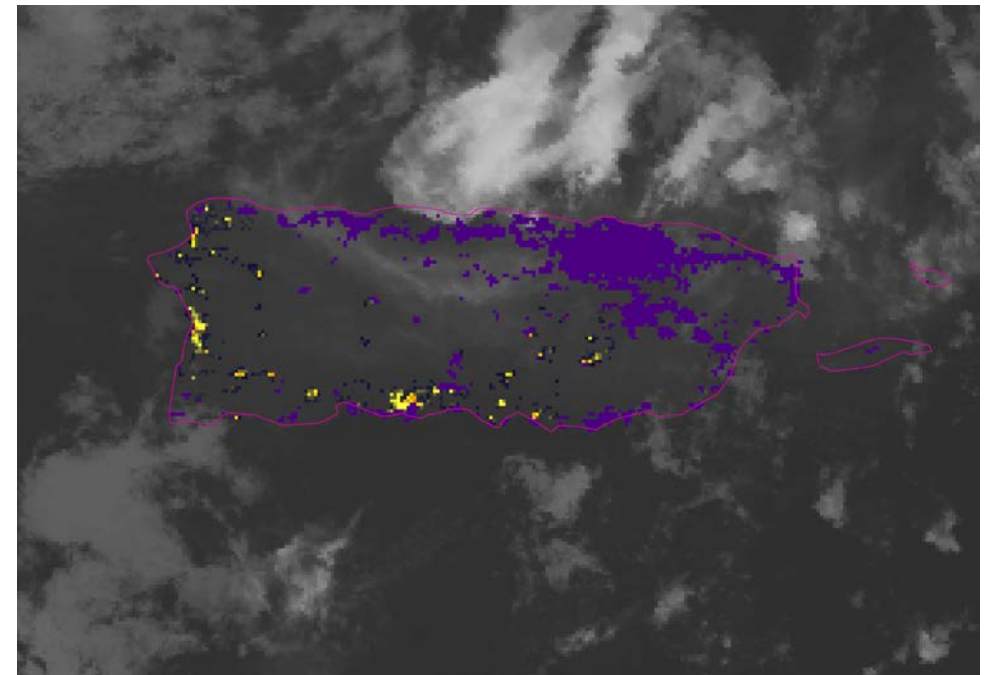
# New Madrid Seismic Zone – National Level Exercise, 2019

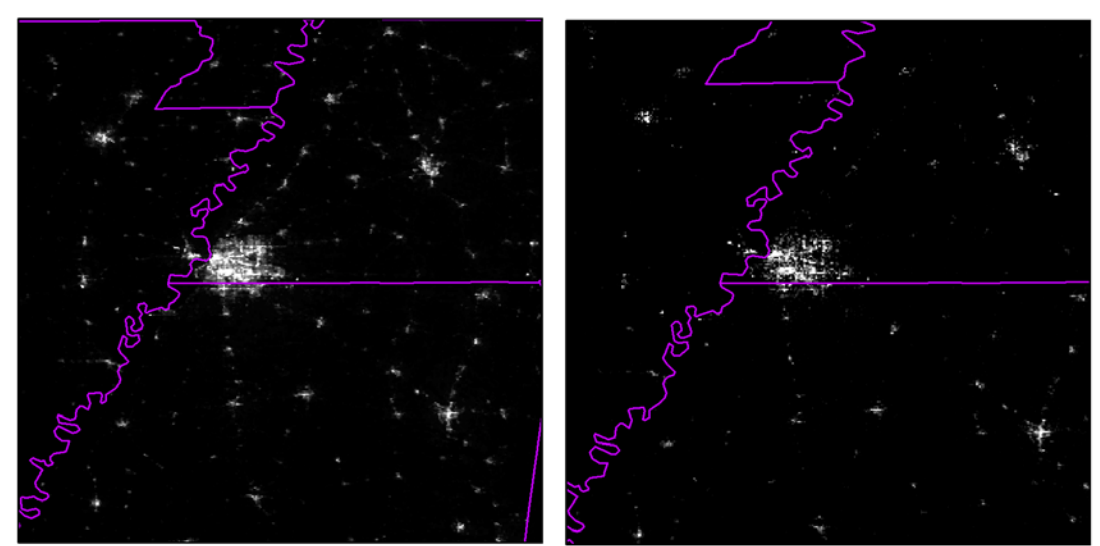Exercise to simulate the response and recovery to 7.7 magnitude earthquake near Memphis, TN.

- Occurred 29 May – 7 June 2019

- Involved multiple stakeholders at local, state and federal level as well as non-government organizations and private sector to assist with the transition and adoption of technologies and protocols.

- Goal to improve the region's collective capacity to respond and recover from significant events

https://www.dhs.gov/sites/default/files/publications/4175_Shaken-Fury-2019_%20Fact%20Sheet_181023_508.pdf



Pre-Event

Post-Event: 20190530 - Exercise

Percent of Normal

20190530 PoN - Exercise

80%
70%
60%
50%
40%
30
20
10
1%
< 1%
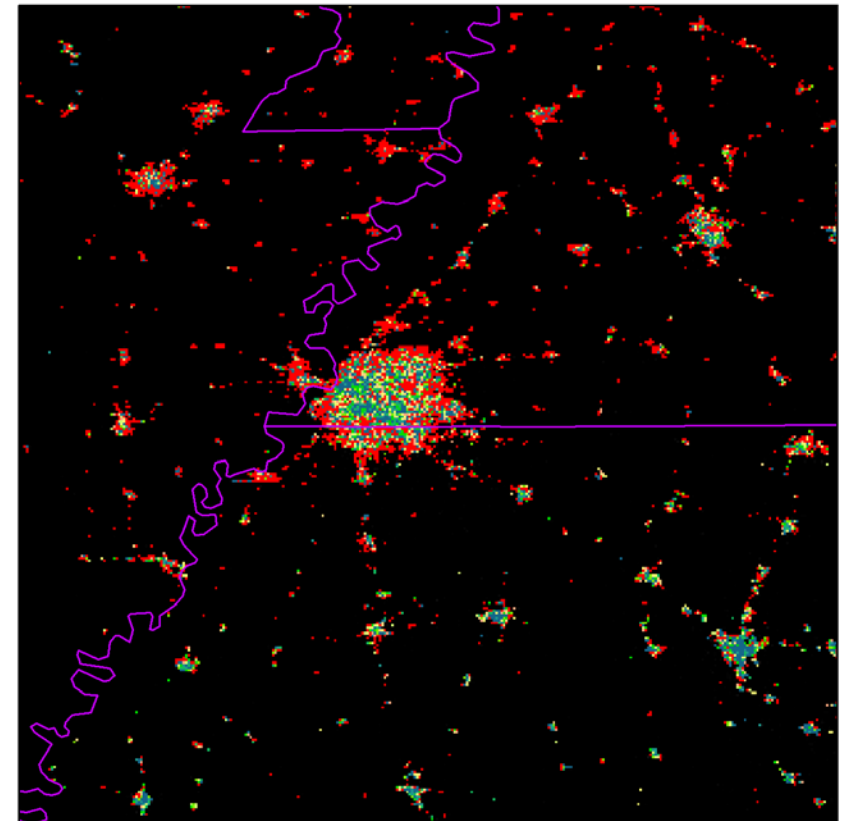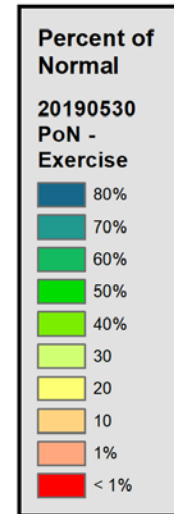
COORDS: 361000N 0864624W
MGRS: 16SEF2036202488
Imagery Date: 28 JAN 2019
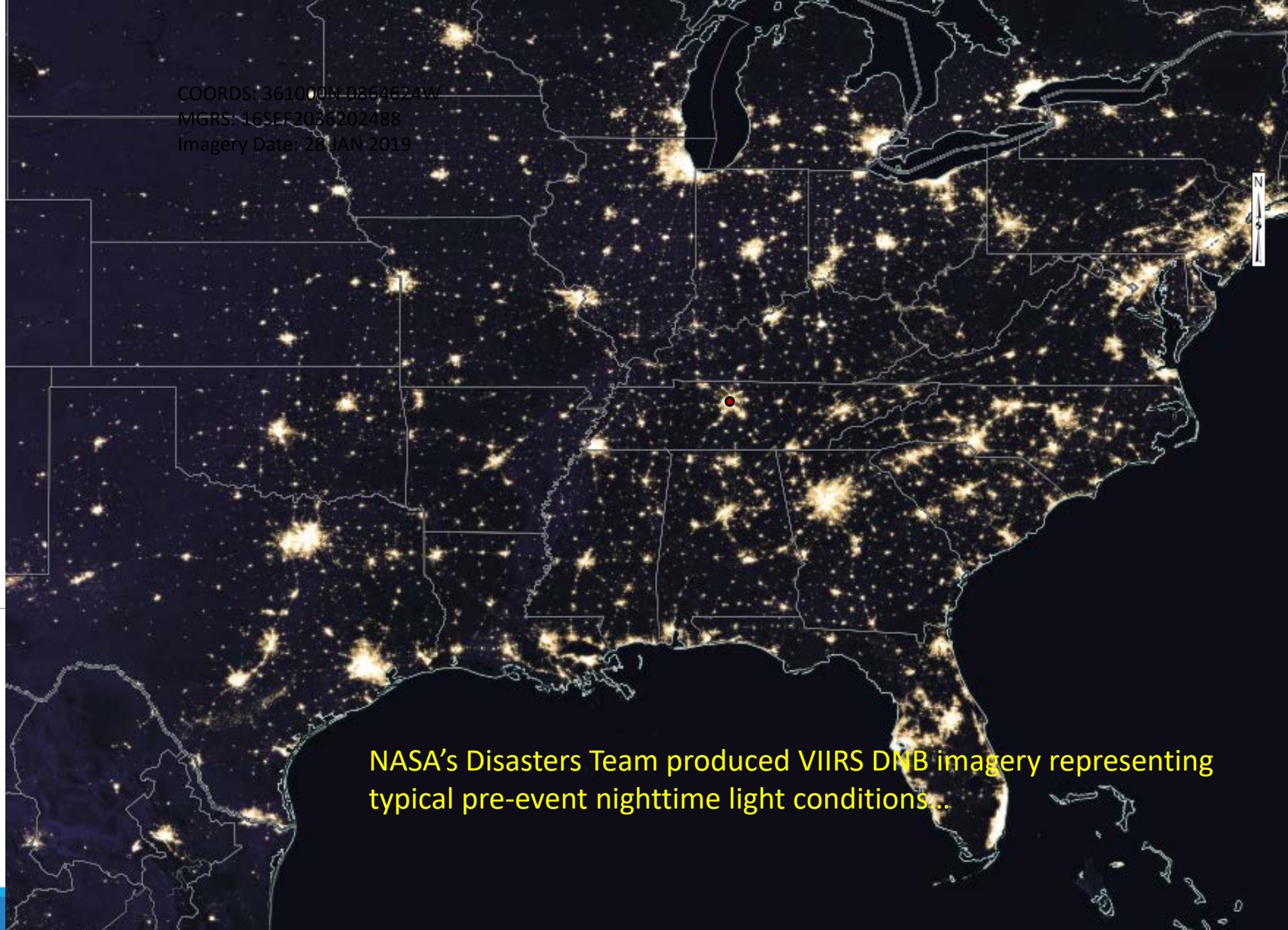
NASA's Disasters Team produced VIIRS DNB imagery representing typical pre-event nighttime light conditions...

COORDS: 361000N 0864624W
MGRS: 16SEF2036202488
Imagery Date: 30 JAN 2019
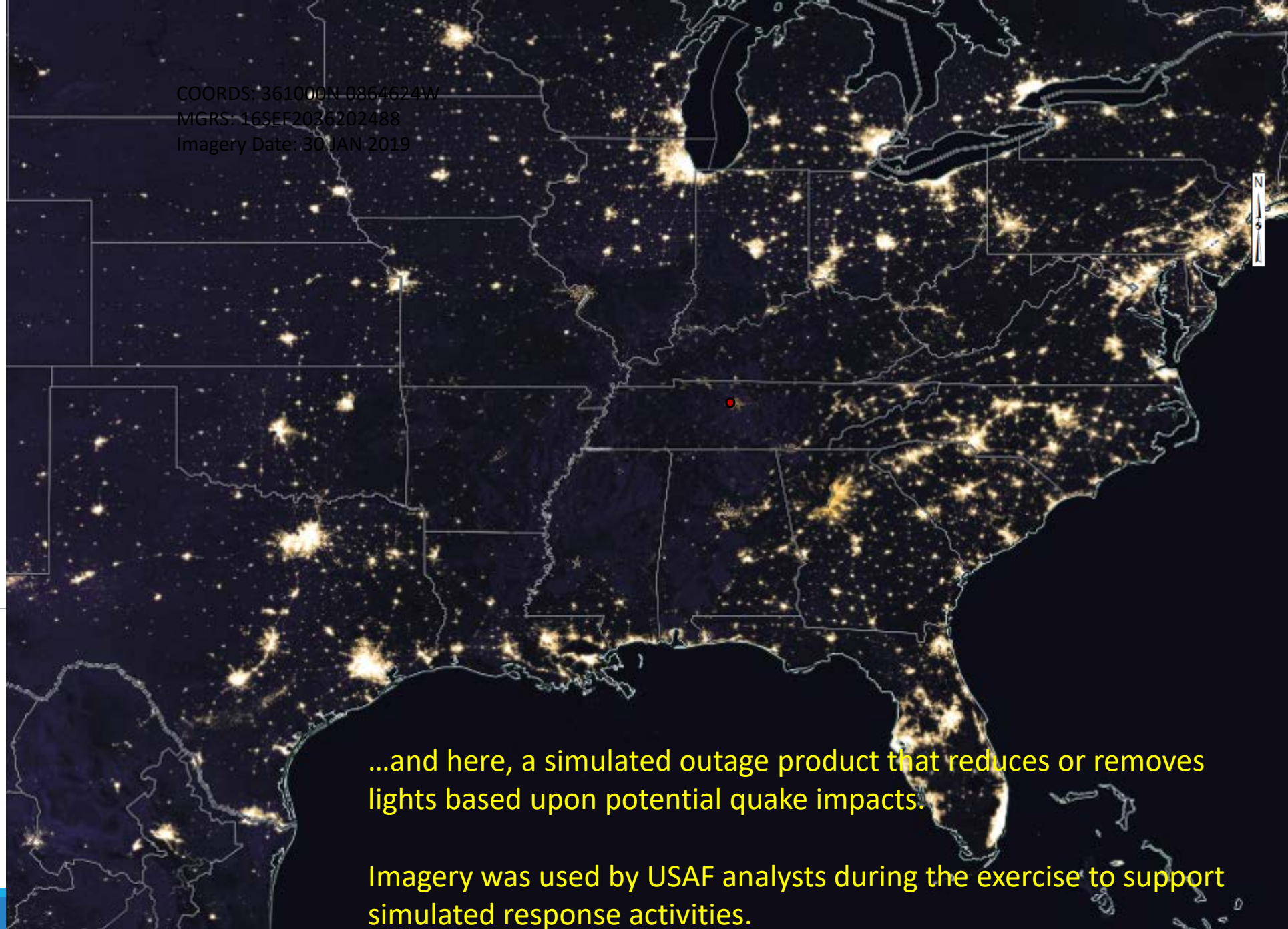
…and here, a simulated outage product that reduces or removes lights based upon potential quake impacts.

Imagery was used by USAF analysts during the exercise to support simulated response activities.

# Spring Flooding – 2019

COPERNICUS SENTINEL 1 A/B & SENTINEL 2 A/B, LANDSAT 8 IMAGERY

Passive support and monitoring began on 1 March 2019 with more involved support starting in mid-March with FEMA interagency partners and the National Guard Bureau – J2 supporting the affected states.

Due to the large scale of the event, satellite data offered a "big-picture" look at the event as it unfolded, over the next few weeks.

This information was provided to support federal, state and local aerial missions in the worst hit areas.
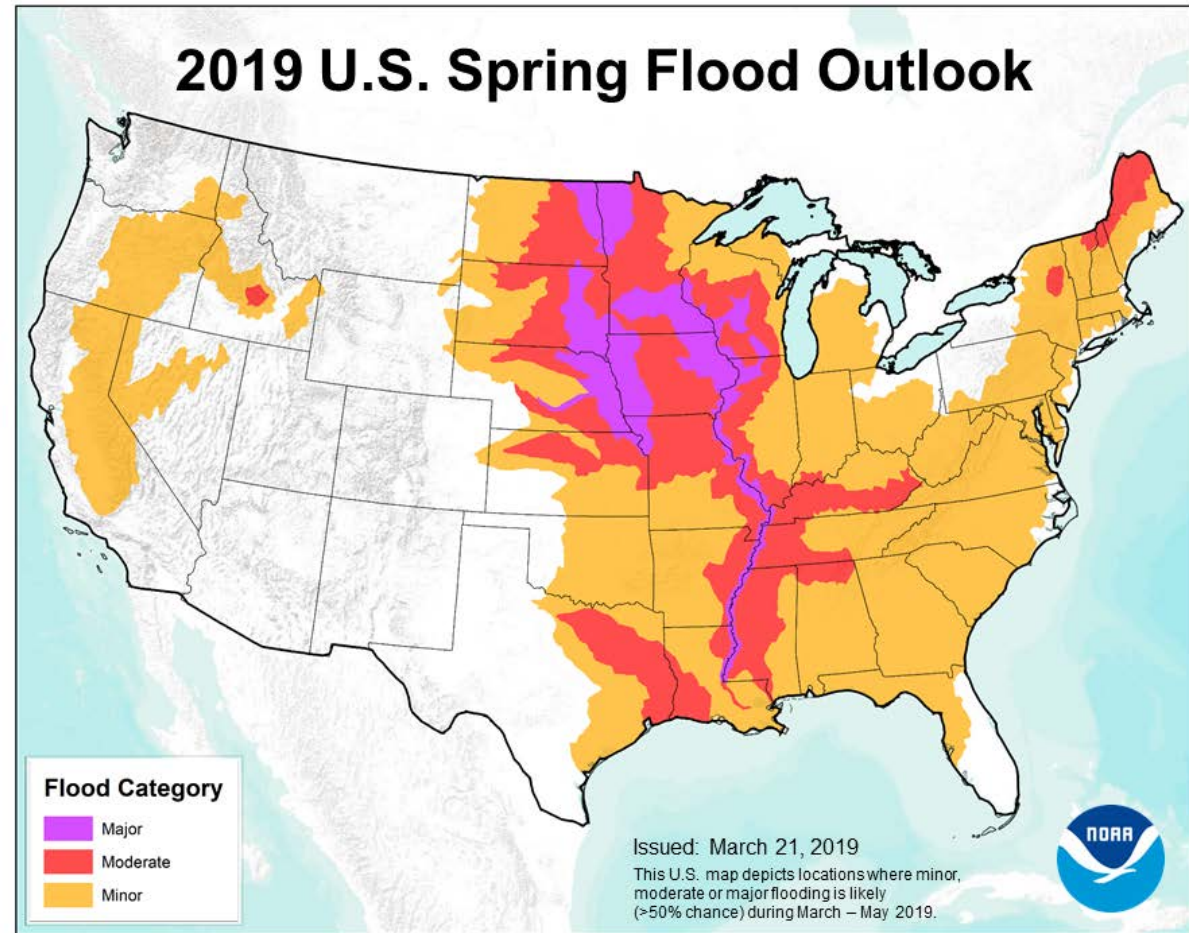


This maps shows areas where there is a greater than 50% change of major, moderate or minor flooding during March through May of 2019

MSFC 2019, *Sentinel-2 (ESA) data courtesy of the U.S. Geological Survey and* contains modified [Copernicus](https://maps.disasters.nasa.gov) Sentinel data 2019

NASA Products for the Midwest Flooding 2019

DISASTERS PROGRAM

Home | Sentinel-1 Water Extent | Sentinel-1 RGB Flood Map | Sentinel-2 Products | Product Gallery

- Natural Color RGB - False color image showing water as blue and vegetation as brown or green.
- True Color RGB - True color image showing how it would appear to the naked eye when viewed from space.
- Modified Normalized Difference Water Index (MNDWI) - Dark green areas are water, light brown areas are saturated soil, and dark brown areas are the driest land.

Why create multiple views of the same data? Each product has its strengths. True Color RGB shows infrastructure and buildings well but muddy flood waters may not be as obvious. The Natural Color RGB shows flood waters more obviously and the MNDWI makes saturated soil more apparent. When the products are viewed side by side it is easier to make a more complete assessment of the flooding impacts.

Resolution:

Natural Color RGB - 20m

True Color RGB - 10m

MNDWI - 10m

Satellite :

Copernicus Sentinel-2 operated by the European Space Agency (ESA)

Credits:

SPoRT Team at NASA Marshall Space Flight Center

Sentinel data used in this derived product, contains modified Copernicus Sentinel data (2019), processed by ESA and analyzed by NASA Marshall Space Flight Center
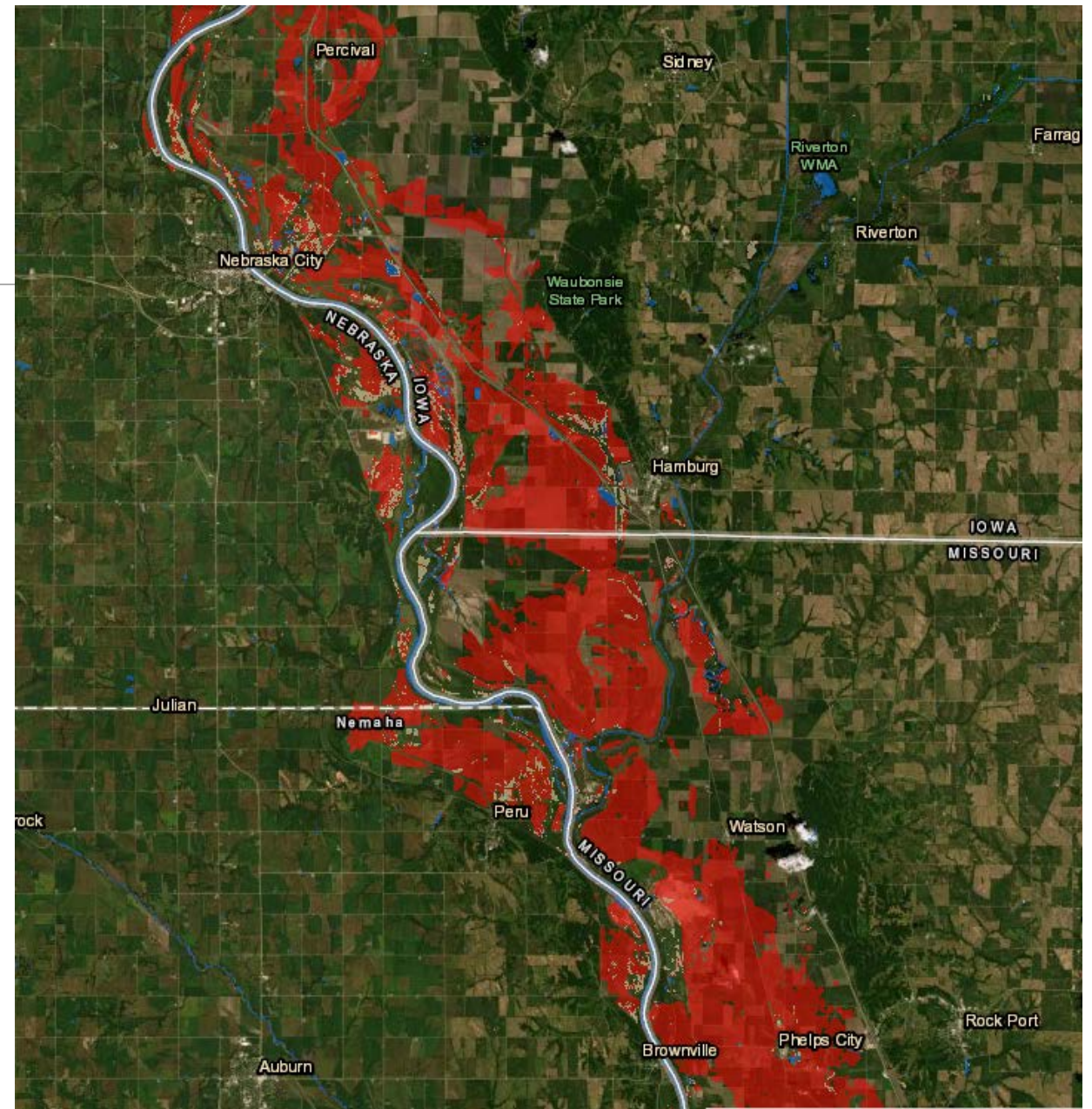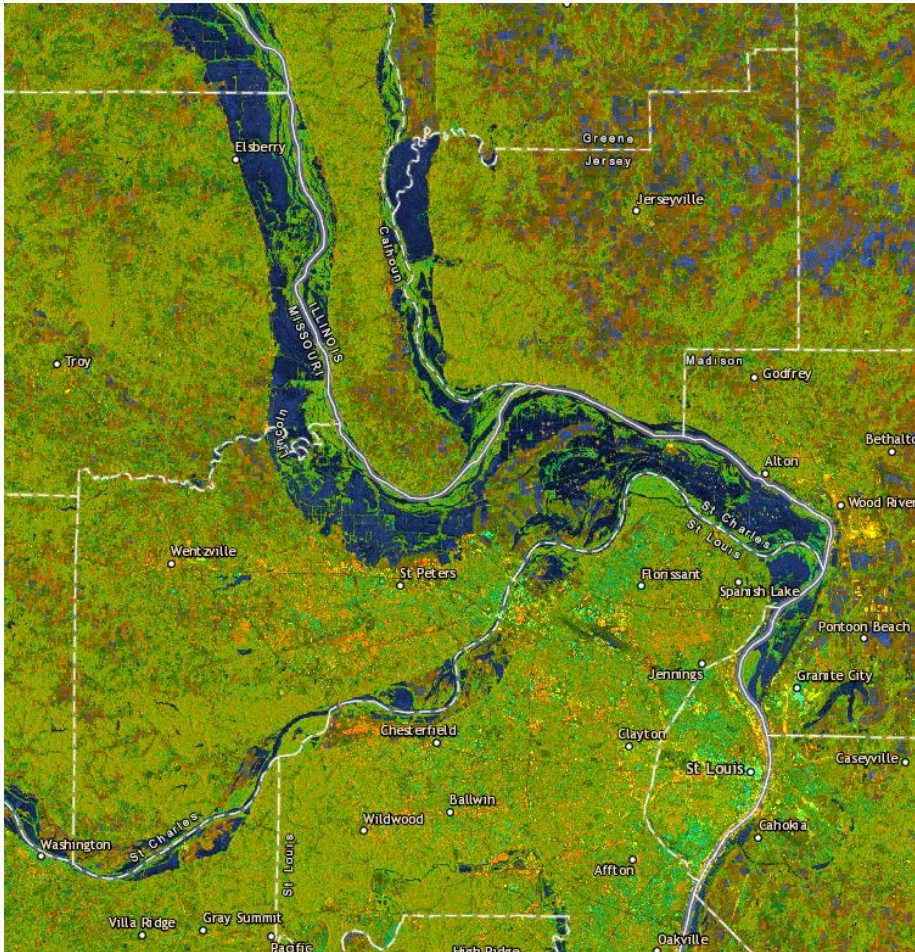
Natural Color RGB | True Color RGB | MNDWI
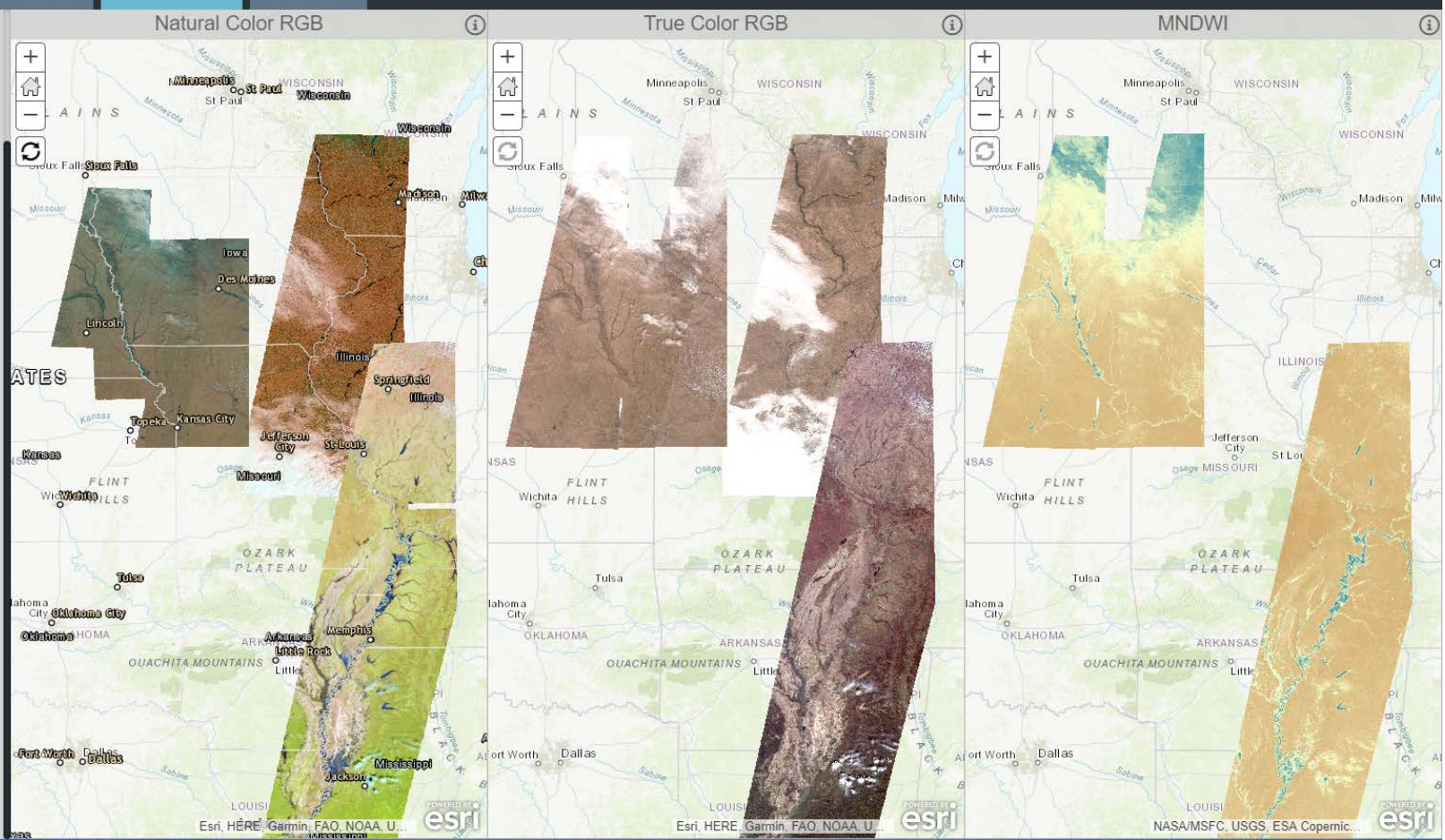
# The use of both SAR and Optical Imagery

Due to both the length of the event (March through late May into June) and the large spatial domain of the flooding event, optical imagery was able to provide additional information of the location and movement of the flood water

Imagery was provided to the National Guard units supporting Nebraska, Arkansas and Missouri, Missouri Emergency Management, and the USDA
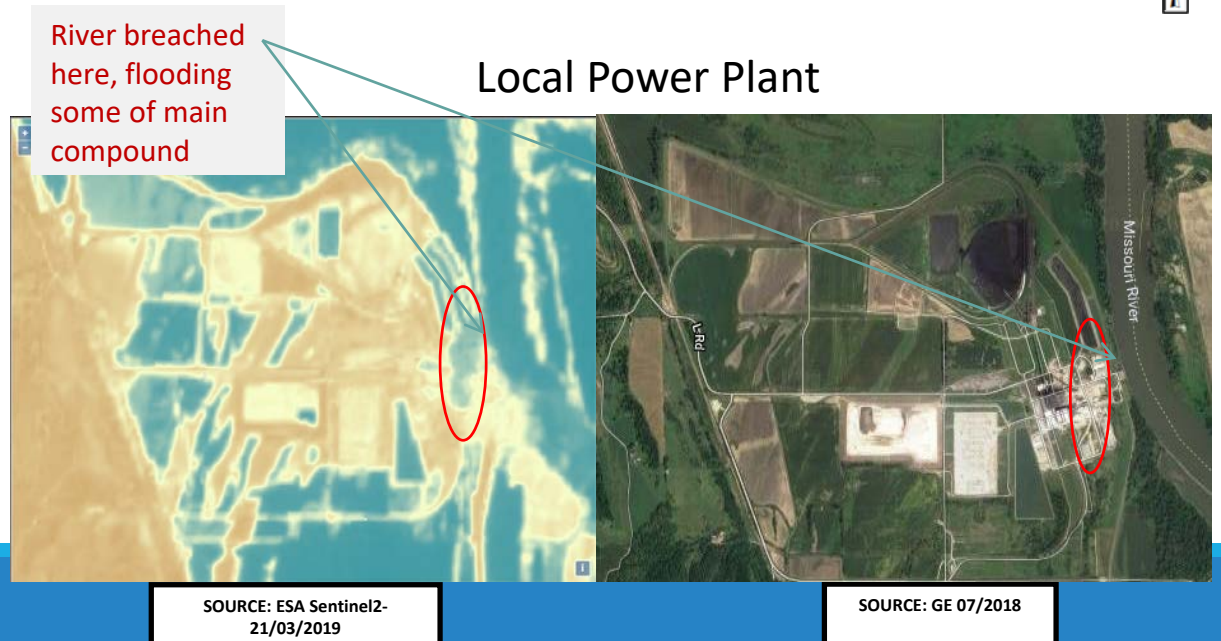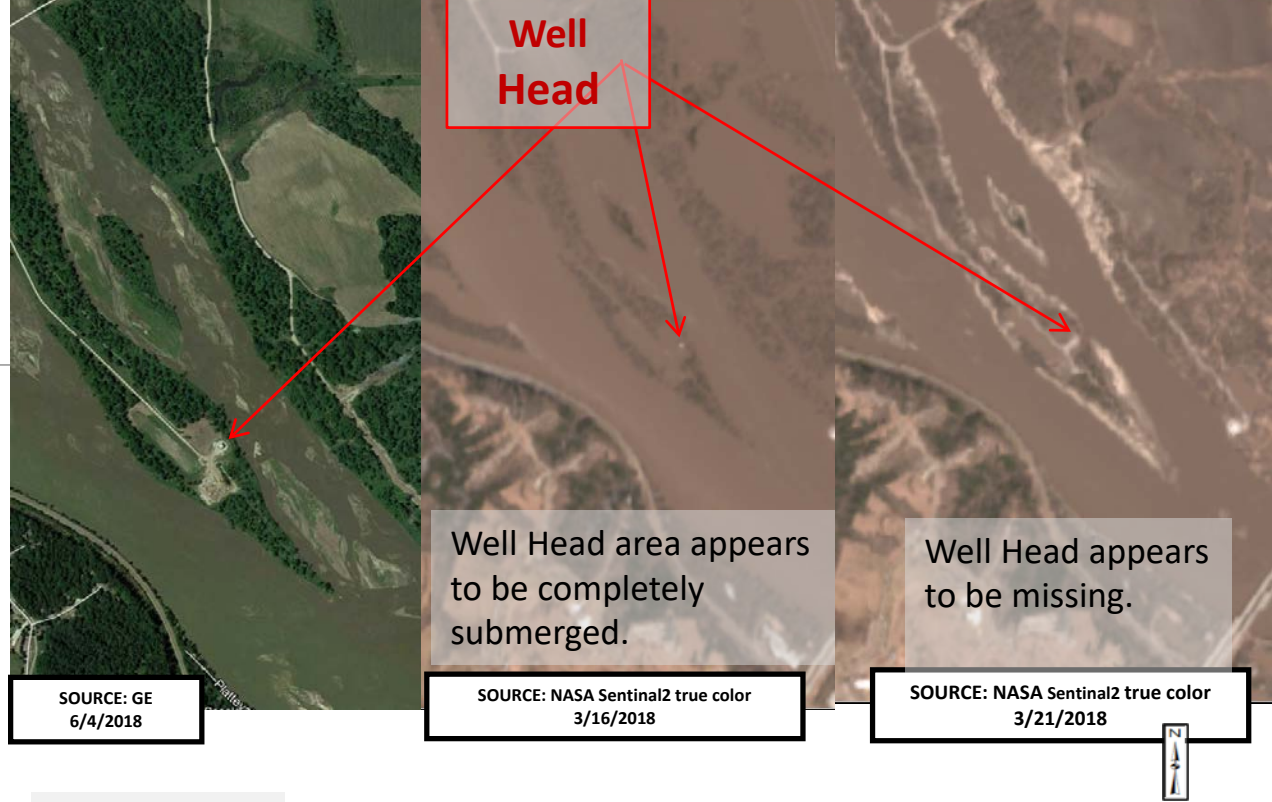
# Sentinel 1 imagery to detect water

# How bad was it?

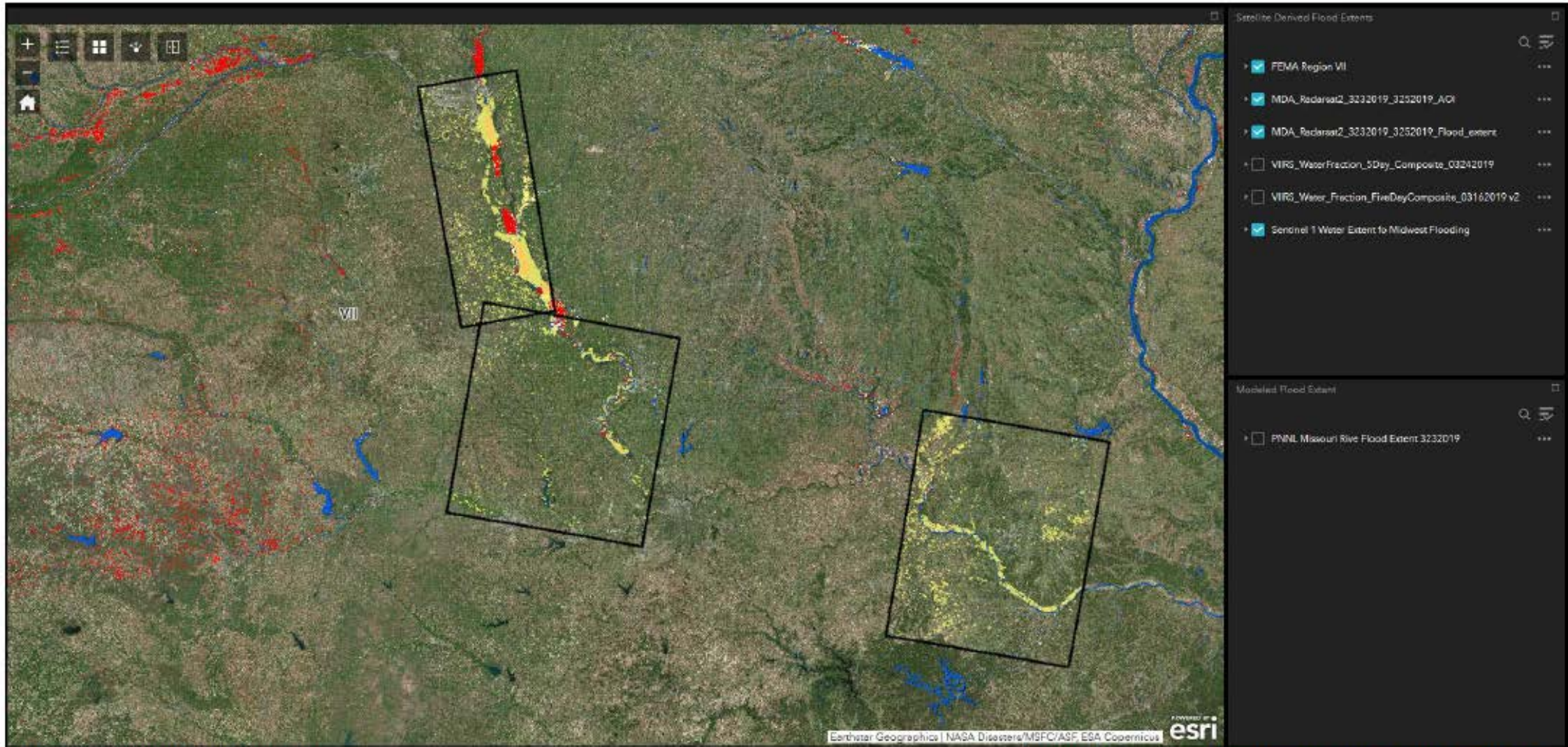Link to the NASA Disasters mapping portal web-app for this event:  https://arcg.is/0TWjqK

March 20, 2018

Offutt Air Force Base

Papillion Creek

March 16, 2019

Offutt Air Force Base

Papillion Creek

https://earthobservatory.nasa.gov/images/144691/historic-floods-inundate-nebraska

**Well Head**

Well Head area appears to be completely submerged.

Well Head appears to be missing.

SOURCE: GE 6/4/2018

SOURCE: NASA Sentinal2 true color 3/16/2018

SOURCE: NASA Sentinal2 true color 3/21/2018

River breached here, flooding some of main compound

## Local Power Plant

Missouri River

SOURCE: ESA Sentinel2-21/03/2019

SOURCE: GE 07/2018

# Satellite and Modeled Flood Extents Dashboard

# Lessons Learned

Understand what the question or problem being observed
- As scientists/data providers, we can tend to have preconceived notions on what the imagery/product/data can be used for
- Ensure that common terminologies have common definitions
  - Different response agencies have varied definitions and understanding of terms

Be prepared for a wide range of skill levels

Design the product to be self-explanatory
- Clearly describe caveats and limitations
- Be mindful of color curves
  - If other products are already being utilized, consider how to use similar colors to minimize incorrect interpretation

Consider a satellite agnostic approach to product production to meet user needs

Listen
- If possible, participate in daily calls as an observer

As much as possible pre/post event, work with supported groups to better define needs and expectations, identify shortcomings, and develop better techniques

# Thank you!

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