

# Informing Disaster Response through Earth Observation: A User-Centric Model for Enhancing Disaster Response Using Geospatial Assets

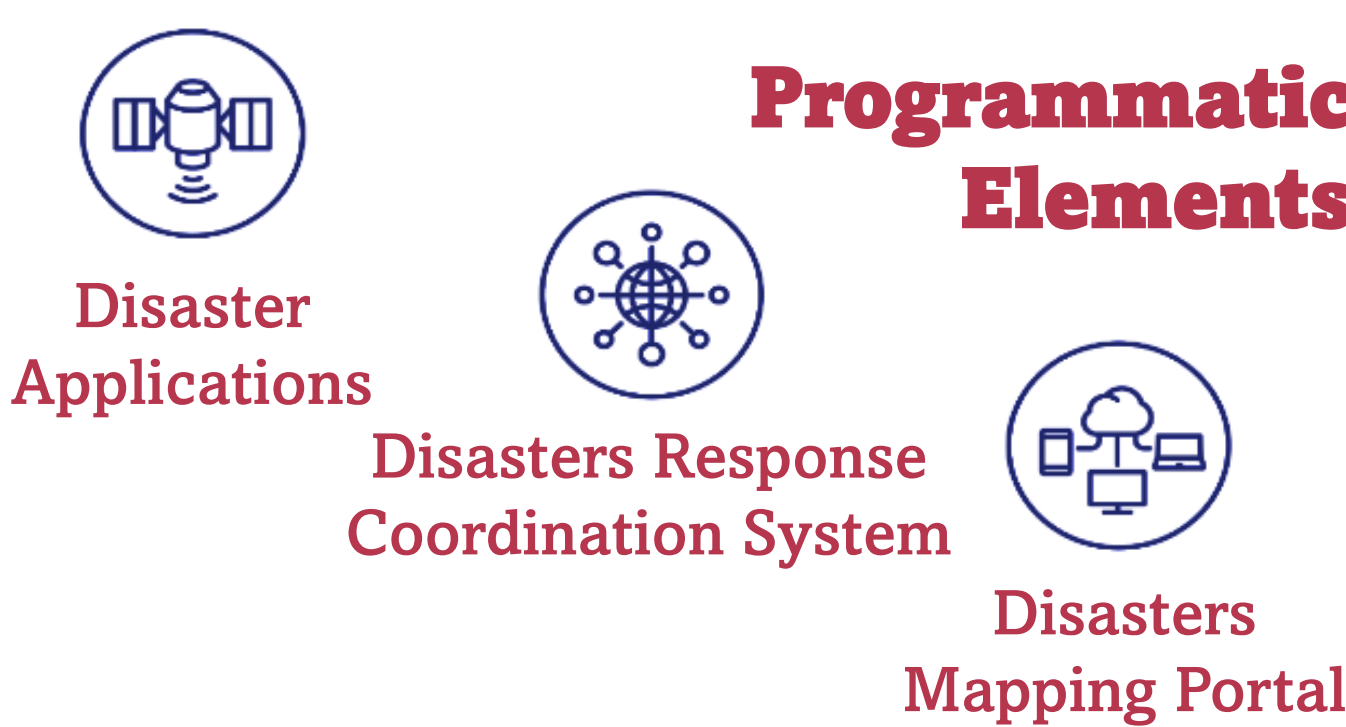
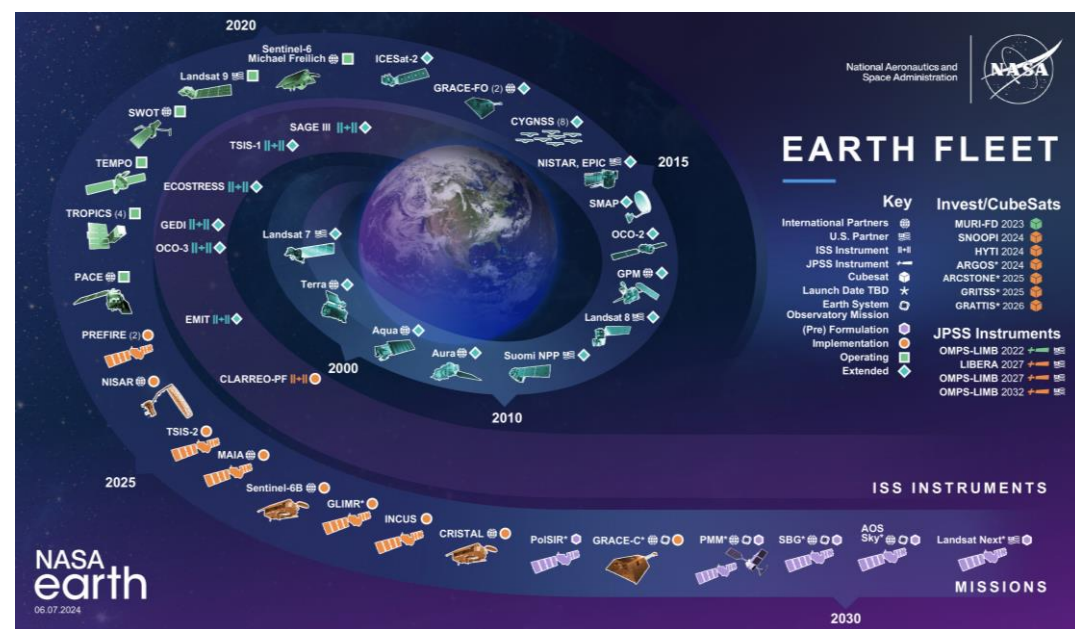
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## ABSTRACT

Satellite observations can provide critical insights to building situational awareness and filling data gaps during disaster response. The National Aeronautics and Space Administration (NASA) Earth Science Division's Disasters Program aims to advance Earth science data and information to support management decisions that prevent or mitigate the impacts of disasters. In support of this goal, NASA's Disasters Response Coordination System (DRCS) employs a "One NASA" approach to coordinate and mobilize the Agency's assets and expertise to provide geospatial information during disasters. The DRCS advances the utility of Earth observation information for supporting disaster response needs and builds skills in the emergency management and disaster response communities through improved coordination, engagement, and learning. The DRCS aims to support reduction of impact to lives and livelihoods by empowering communities to more effectively respond to disasters. The DRCS is organized across six NASA centers and managed by a project office located at NASA Langley working in alignment with NASA Headquarters. The DRCS employs a user-centered framework that begins with requests from disaster responders (state, local, federal government and non-profits working at a national scale) and ends with after-action assessments that feed lessons learned and process improvements. This poster introduces the DRCS model and approach to expanding the use of Earth observations and geospatial information to support disaster response, share use cases for recent event activations working with decision-making organizations, and highlight initial lessons learned.

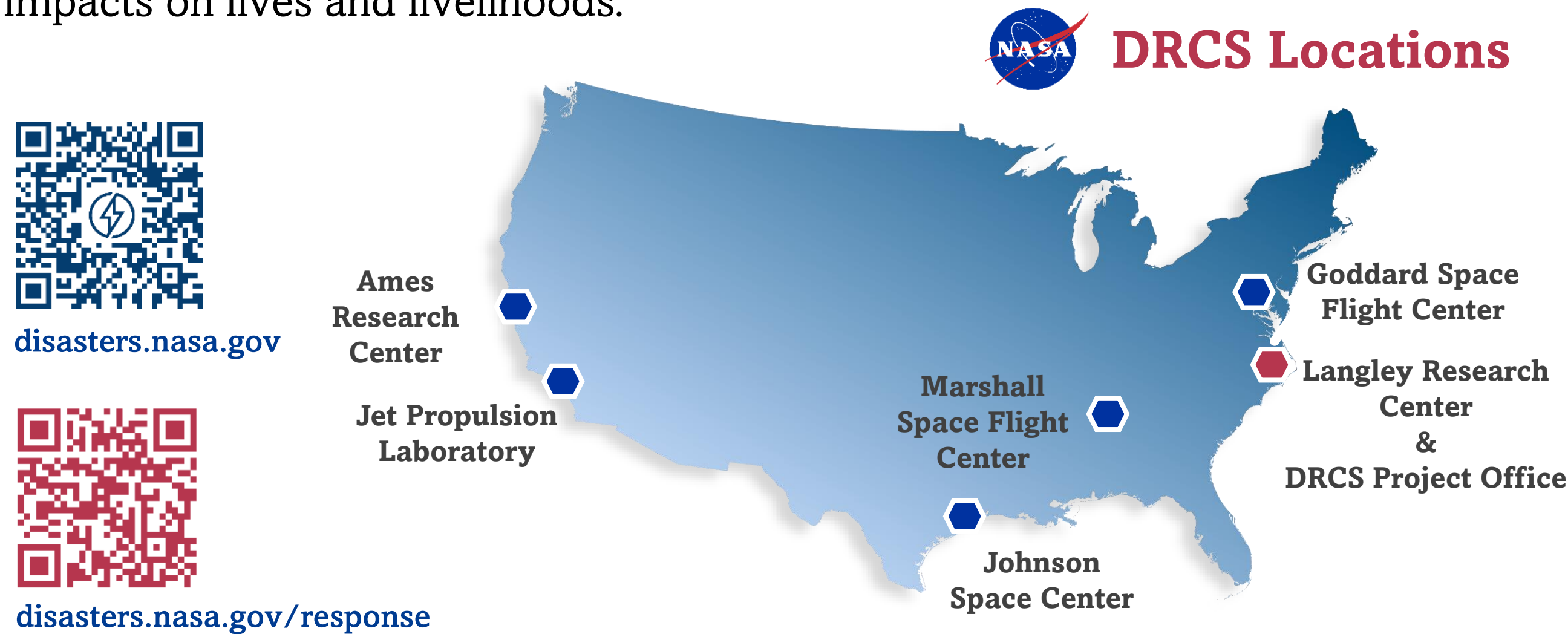
### NASA Disasters Program

The NASA's Earth Science Division uses the global vantage point of space, to build fundamental, scientific knowledge about Earth and how it is changing. ESD advances understanding of Earth as an integrated system and develops and tests applications that deliver direct societal benefit. Within ESD, the Disasters Program advances science and builds tools to help communities make informed decisions for disaster planning. Before, during and after disasters strike, the Disasters Program provides partners with actionable data to recover from disaster impacts and build resilient communities.



### Disasters Response Coordination System

The NASA Disasters Program's DRCS applies a whole-of-NASA approach that leverages Earth science, technology, and expertise to provide trusted and actionable information to organizations actively responding to disasters. The DRCS is request driven, working with government agencies, NGOs and private sector partners to provide insights that inform decision making and reduce impacts on lives and livelihoods.

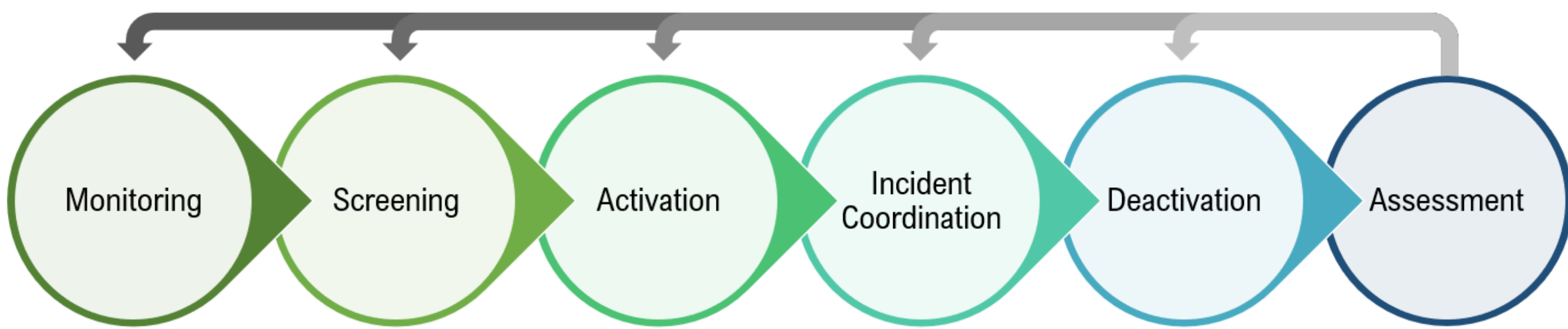


The DRCS is request driven. Requests can come from disaster response and emergency management organizations, such as:

- State, local, Tribal, or federal government entities
- Non-profit organizations working at the national scale
- International governments
- Organizations focused on emergency management and/or disaster response.

Requests should be sent by email to [DRCS@nasa.gov](mailto:DRCS@nasa.gov).

## DRCS RESPONSE CYCLE

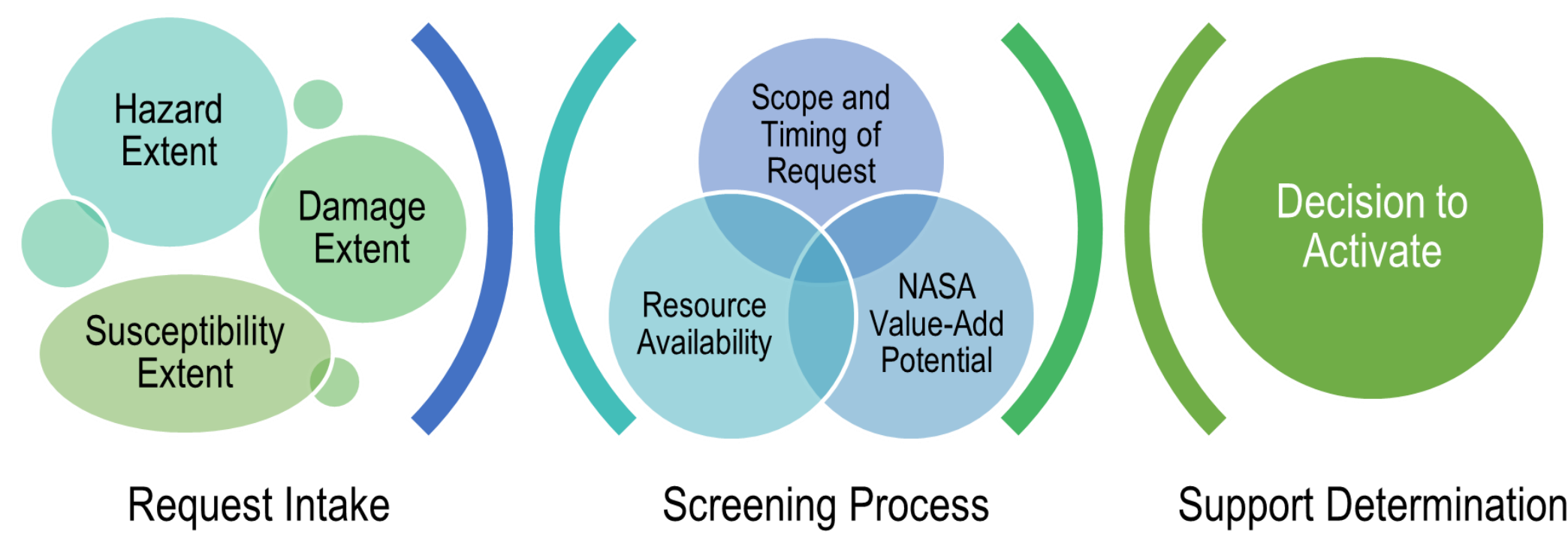


### Monitoring

The DRCS network maintains situational awareness of impending and actual disasters with potentially significant humanitarian, infrastructural, social, or economic impacts. Some natural hazards occur in remote or uninhabited areas and are unlikely to cause such impacts, but DRCS also maintains awareness of these events if information gleaned from observations may benefit research at NASA and partner agencies.

### Screening

The DRCS requires a request from an organization involved in disaster response and/or emergency management to elevate from the Monitoring to the Screening step.



### Activation

Once a request is made and an event meets established criteria, the DRCS assigns a team to lead collaboration and incident coordination begins.

### Incident Coordination

Incident Coordination includes timely and organized information and data sharing, streamlined communications across DRCS and within NASA, communications with requestors and partners, data acquisition, product development (as appropriate), and handoff of data/products to requestors. Incident Coordination involves a cyclical process of receiving requests, developing products, and supporting partners.

### Deactivation

Upon verification from the requestor that their request is fulfilled or if after 72 hours elapse since the last communication received following DRCS communication outreach, the DRCO will make the decision to proceed to the deactivation of the response.

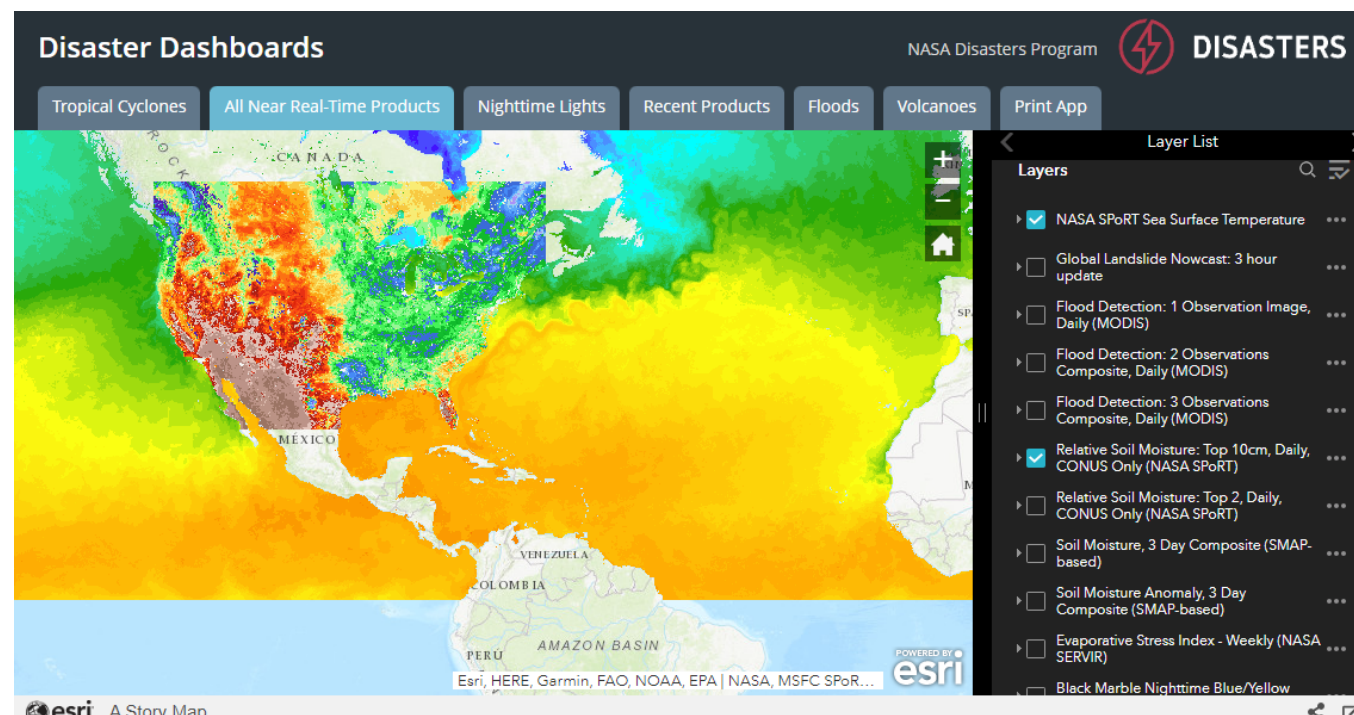
### Assessment

The DRCS pursues a systematized approach to monitoring, evaluation, and learning (MEL) to drive adaptation and efficacy. MEL activities include a robust after-action assessment process centered around collection of lessons learned with a review cycle to take these inputs and feed them back into the DRCS processes.

## Disasters Mapping Portal

The Disasters Mapping Portal is a free and open **geographic information systems** (GIS) portal hosting a wide array of disaster products and near real-time dashboards. It serves as the primary interface for sharing maps, data, and analysis with response stakeholders.

- Standardized GIS format allows easy integration into decision-support tools.
- Every product has REST and WMS endpoints
- Most services discoverable on ArcGIS Online
- Most imagery files can be downloaded
- No login requirements
- Two types of products:
  1. Event-based Products
  2. Near Real-Time Products



[maps.disasters.nasa.gov](https://maps.disasters.nasa.gov)

## ACTIVATION EXAMPLES

### DRCS Response to the 2024 Hurricane Season

During the 2024 Atlantic hurricane season, the DRCS activated for seven hurricanes and tropical storms (Beryl, Debby, Ernesto, Francine, Helene, and Milton, and Sara) working with requestors across 10 U.S. states, one U.S. territory, and two countries (U.S. and Costa Rica). The DRCS provided 67 products through the seven event galleries to enhance situational awareness and inform response efforts relating to applications such as:

- Where communities face power outages
- Extent of flooding and surface water extent during and after storms
- Potential landslide locations and 'hotspots' that impact communities and transportation routes
- Soil moisture to highlight areas more susceptible to flooding
- Understanding where vegetation has been disturbed to highlight areas potentially impacted by high winds and flash flooding

## Hurricanes Helene & Milton

Hurricane Helene caused significant flooding, landslides, power outages, and damage across Florida, Georgia, South Carolina, North Carolina, Virginia, and Tennessee, impacting a land area over 150,000 square miles. The DRCS collaborated directly with FEMA, state emergency management agencies from Florida, Georgia, North Carolina, and Tennessee, the American Red Cross, the United States Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), and other federal agencies to enhance situational awareness and provide decision-support products. The DRCS provided support response from Sept 24 – Oct 24, 2024.

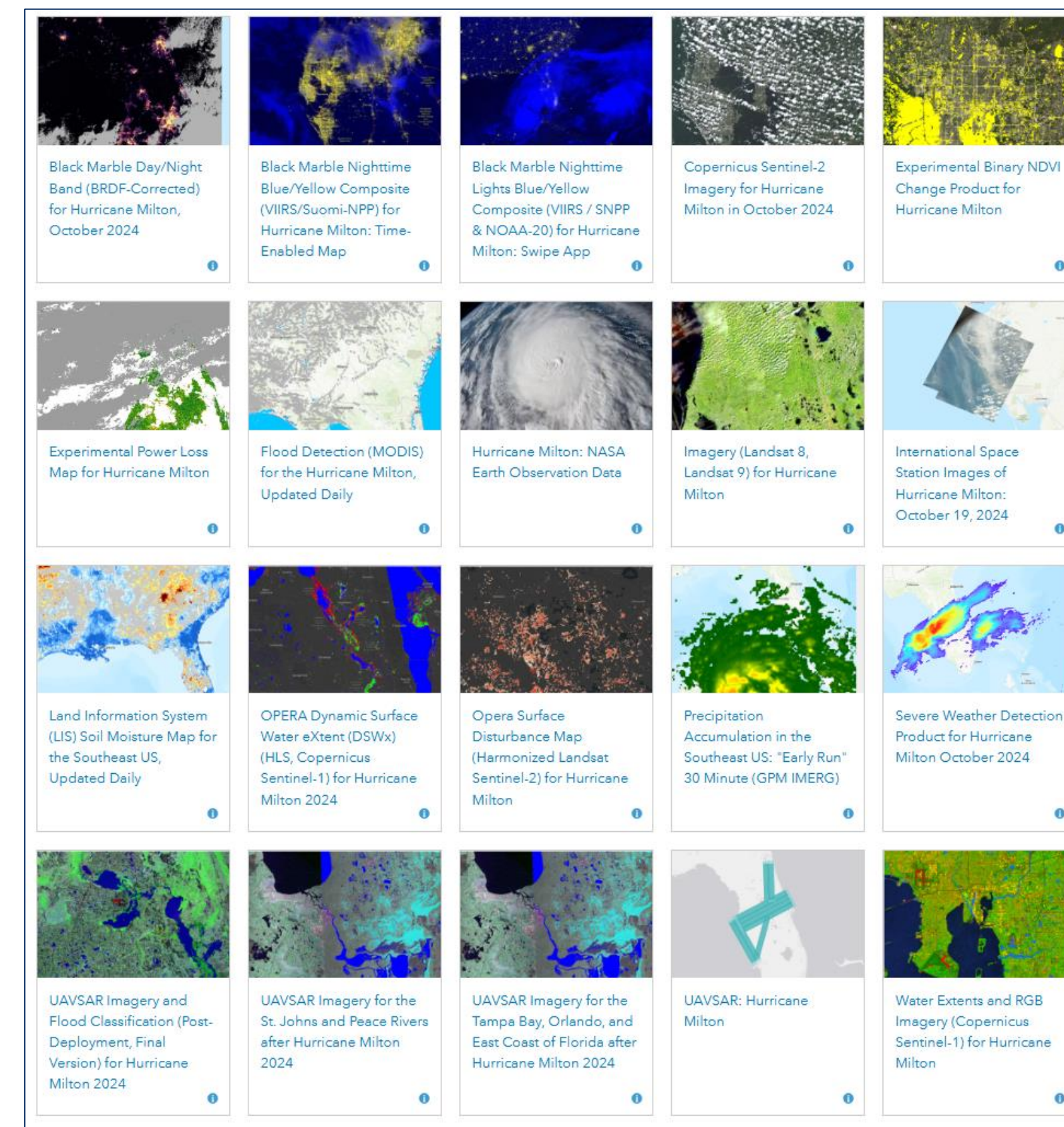
Hurricane Milton made landfall in Florida only days after Hurricane Helene devastated the southeastern United States, bringing significant flooding, wind damage, and power outages for millions in central Florida. The DRCS provided Hurricane Milton response support between October 7-31, collaborating directly with FEMA, the State of Florida Geospatial Information Office, USGS, NOAA, the American Red Cross, and other response partners.



Hurricane Helene Story Map



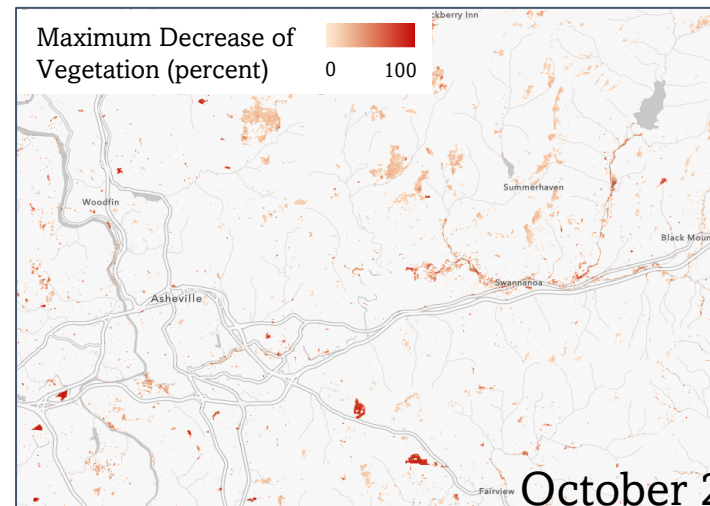
Hurricane Milton Story Map



Product gallery for the DRCS Hurricane Milton response.

### Example Products Provided

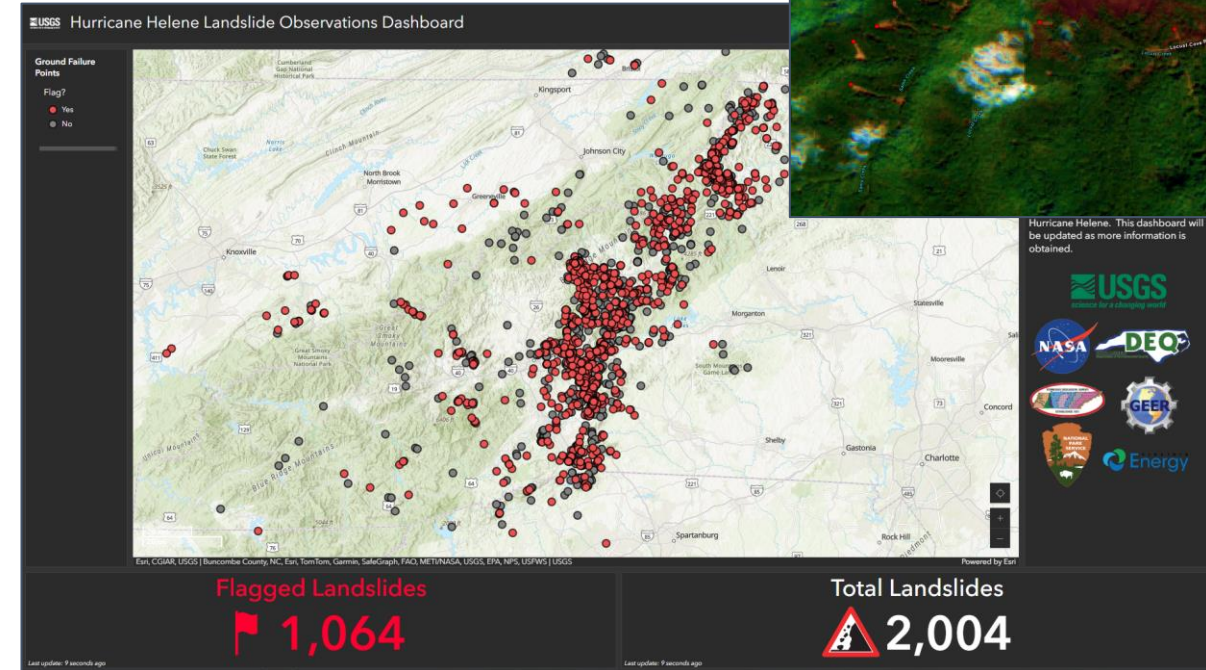
#### Vegetation Disturbance



The Advanced Rapid Imaging and Analysis (ARIA) and Observational Products for End-Users from Remote Sensing Analysis (OPERA) teams at NASA's Jet Propulsion Laboratory and CalTech derived disturbance maps using the OPERA Disturbance Alert from Harmonized Landsat-Sentinel-2 products, which mapped per pixel vegetation disturbance (specifically, vegetation cover loss).

The product contains modified Copernicus Sentinel data (2024) and is produced as part of the OPERA project, which is funded by NASA to address remote sensing needs identified by the Satellite Needs Working Group. Managed by JPL, OPERA funds and manages the D207-LEP7-HLS product developed and produced by the Global Land Analysis and Discovery (GLAD) laboratory at the University of Maryland.

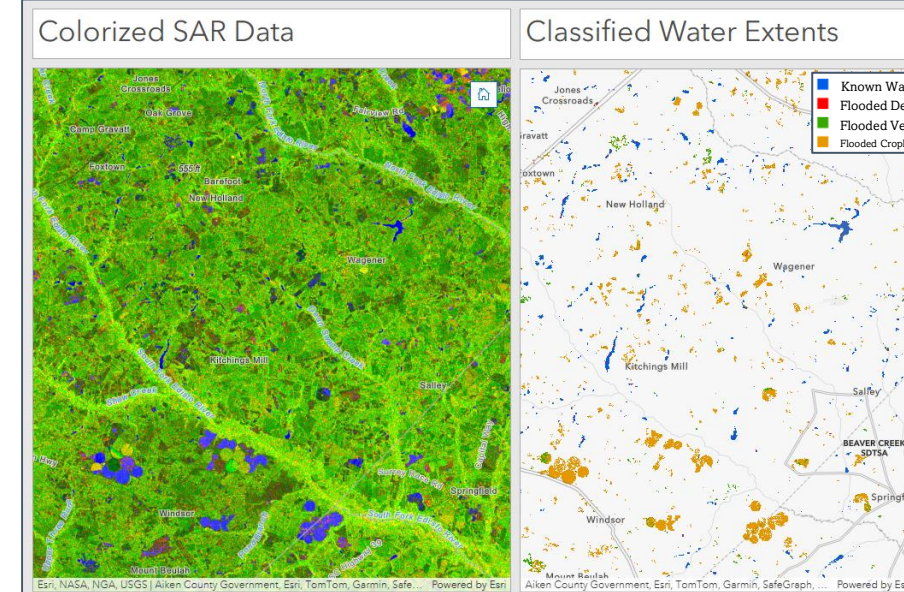
#### Landslide Points



The NASA Goddard Space Flight Center Landslides Team manually mapped landslides over affected areas in collaboration with the USGS Landslide Assessments, Situational Awareness, and Event Response Research (LASER) team. Sentinel-2 and other optical imagery was used to aid in mapping. The team contributed almost 400 landslide points to the USGS landslides dashboard map (left). The image to next to the dashboard is a Sentinel-2 scene from October 7 used to map landslides for this effort.

Contains modified Copernicus Sentinel data (2024) processed by ESA.

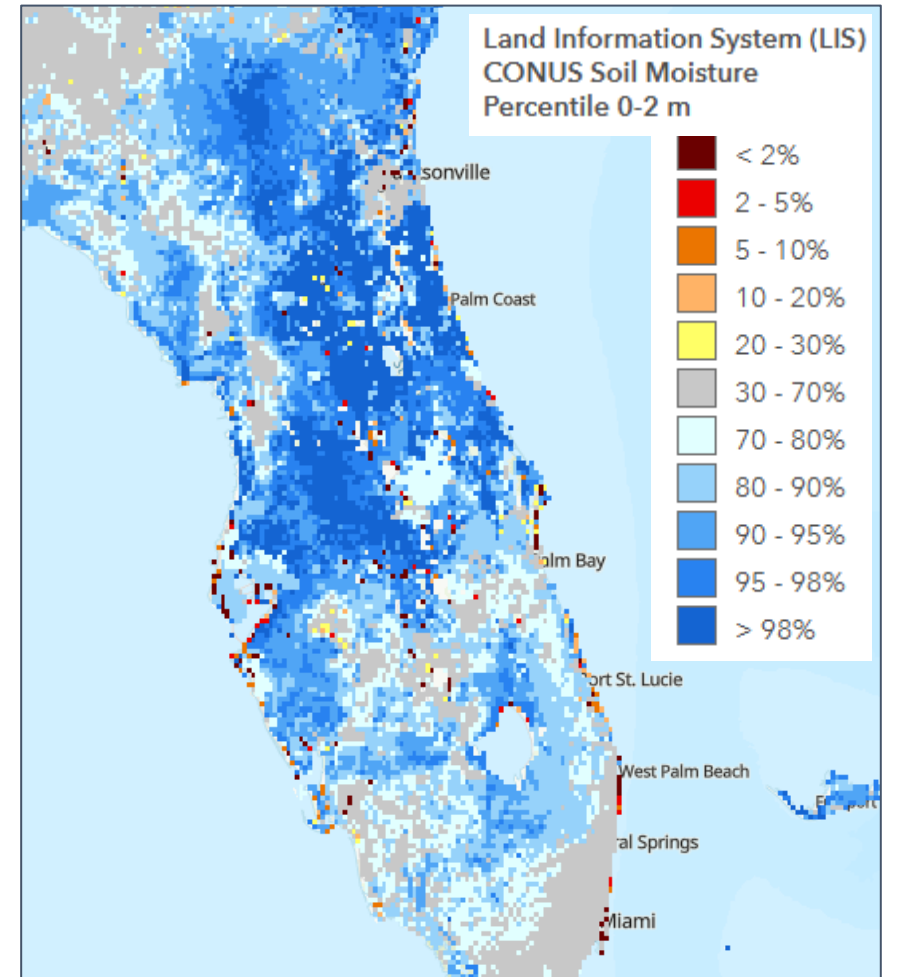
#### RGB Composites & Surface Water Extent



The Alaska Satellite Facility developed false color Red, Green, Blue (RGB) and Radiometrically Terrain-Corrected (RTC) composites and surface water extent products of the Sentinel-1A/B SAR instrument. When used to support a flooding event, areas in blue denote water present at the time of the satellite overpass. This map shows flood extents derived from Sentinel-1 SAR decompositions in parts of North and South Carolina. Pre-incident data was collected on September 16, and post-event data was collected September 26, September 28, and October 3.

Contains modified Copernicus Sentinel data (2024) processed by ESA.

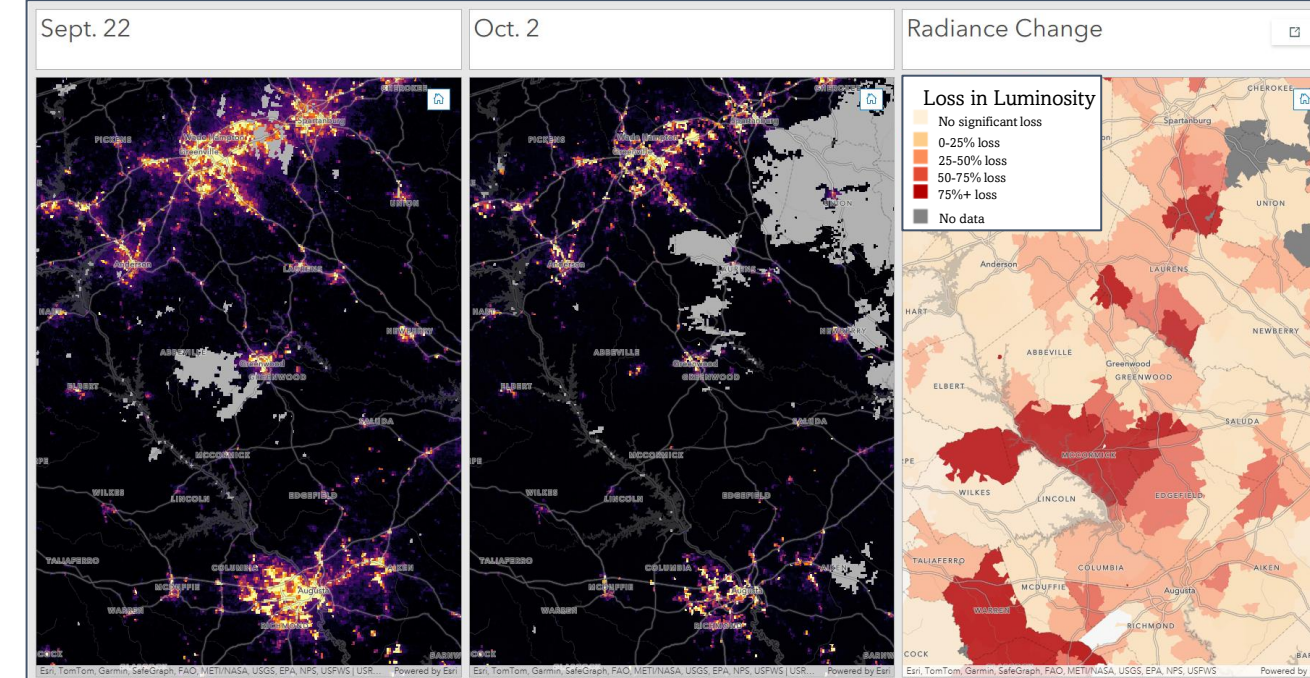
#### Soil Moisture Percentiles



The NASA Land Information System (LIS) is a high-performance land surface modeling and data assimilation system used to characterize land surface states and fluxes by integrating satellite-derived datasets, ground-based observations, and model analyses. The NASA Short-term Prediction Research and Transition (SPoRT) center at Marshall Space Flight Center (MSFC) developed a real-time configuration of the LIS ("SPoRT-LIS"), which is designed for use in experimental operations by domestic and international users. For disaster response, the LIS 0-200 cm Soil Moisture Percentile layer provides soil moisture estimates at approximately 3-km horizontal grid spacing over a 2-meter-deep soil column and has been validated for regional applications and against U.S. Drought Monitor products. The present-day soil moisture analyses are compared to daily historical distributions to determine the soil wet/dry anomalies for the specific day of the year.

Image courtesy of the NASA Marshall Space Flight Center SPoRT Center and NASA Land Information System from October 2024.

#### Nighttime Light Radiance Change



Nighttime lights data were created by the NASA Goddard Black Marble Science Team and published daily from Sept. 18 throughout the activation. These maps compare pre-incident nighttime lights (left) with a post-incident scene (center) and an experimental radiance change map aggregated by zip code (right) to localize possible power outages and impacts, which is under development by the DRCS. Red areas experienced the most loss in luminosity, while gray indicates no data or cloud coverage.

Roman et al. Satellite-based assessment of electricity restoration efforts in Puerto Rico after Hurricane Maria. PLoS one. 2019 Jun 28;14(6):e0218883. & Roman et al. NASA's Black Marble nighttime lights product suite. Remote Sensing of Environment. 2018 Jun 1;210:114-48.

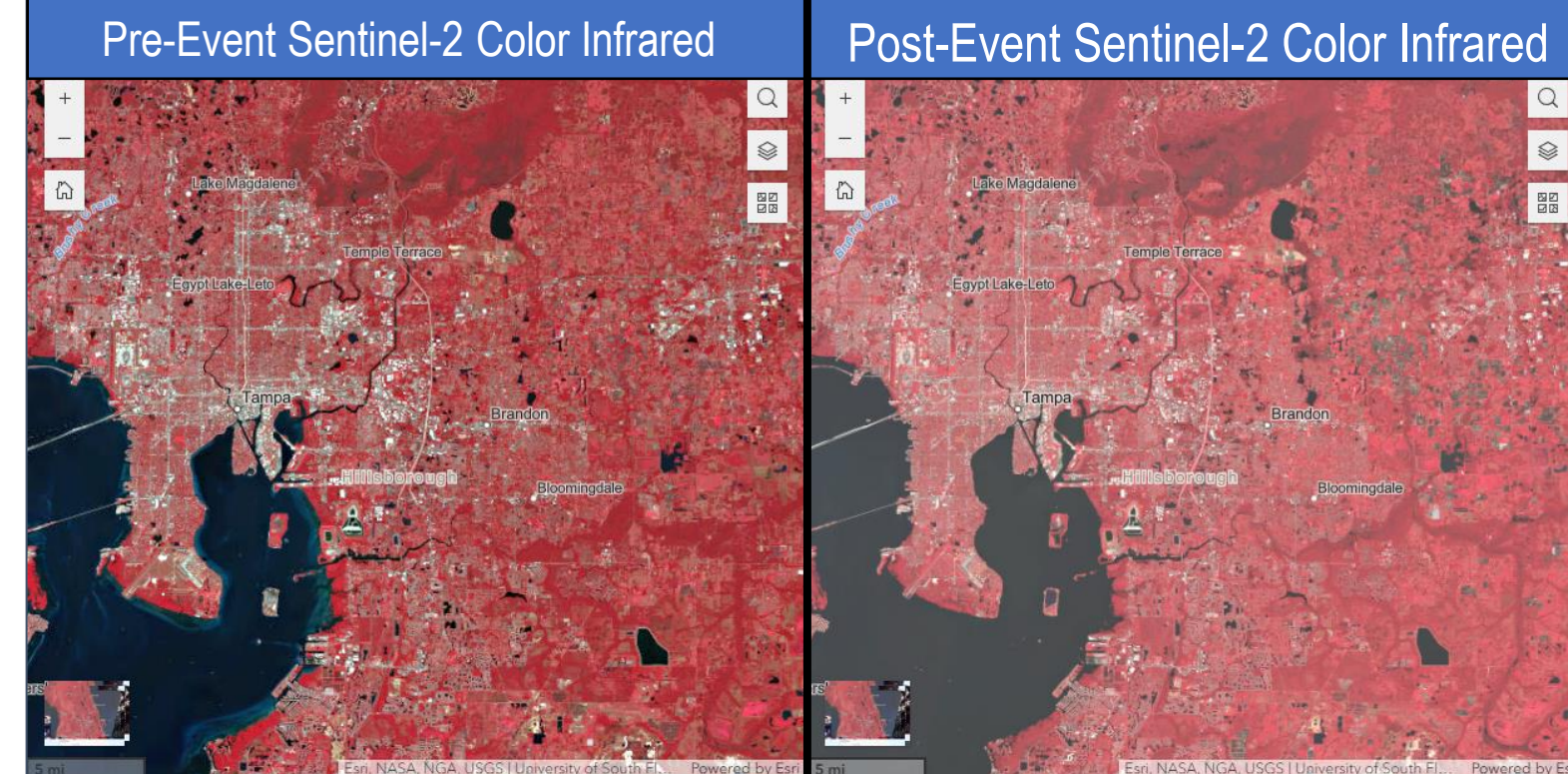
#### Astronaut Photography



Photography collected by the International Space Station (ISS) crew is georeferenced and shared for situational awareness and applications such as optical flood mapping. Provided by the ISS Program and Johnson Space Center's Earth Science & Remotes Sensing Unit, ISS crew handheld photography supported the response efforts for both Helene and Milton.

Photograph of Bradenton, Florida taken October 19, 2024 (left). Image courtesy of the Earth Science and Remote Sensing Unit, NASA Johnson Space Center.

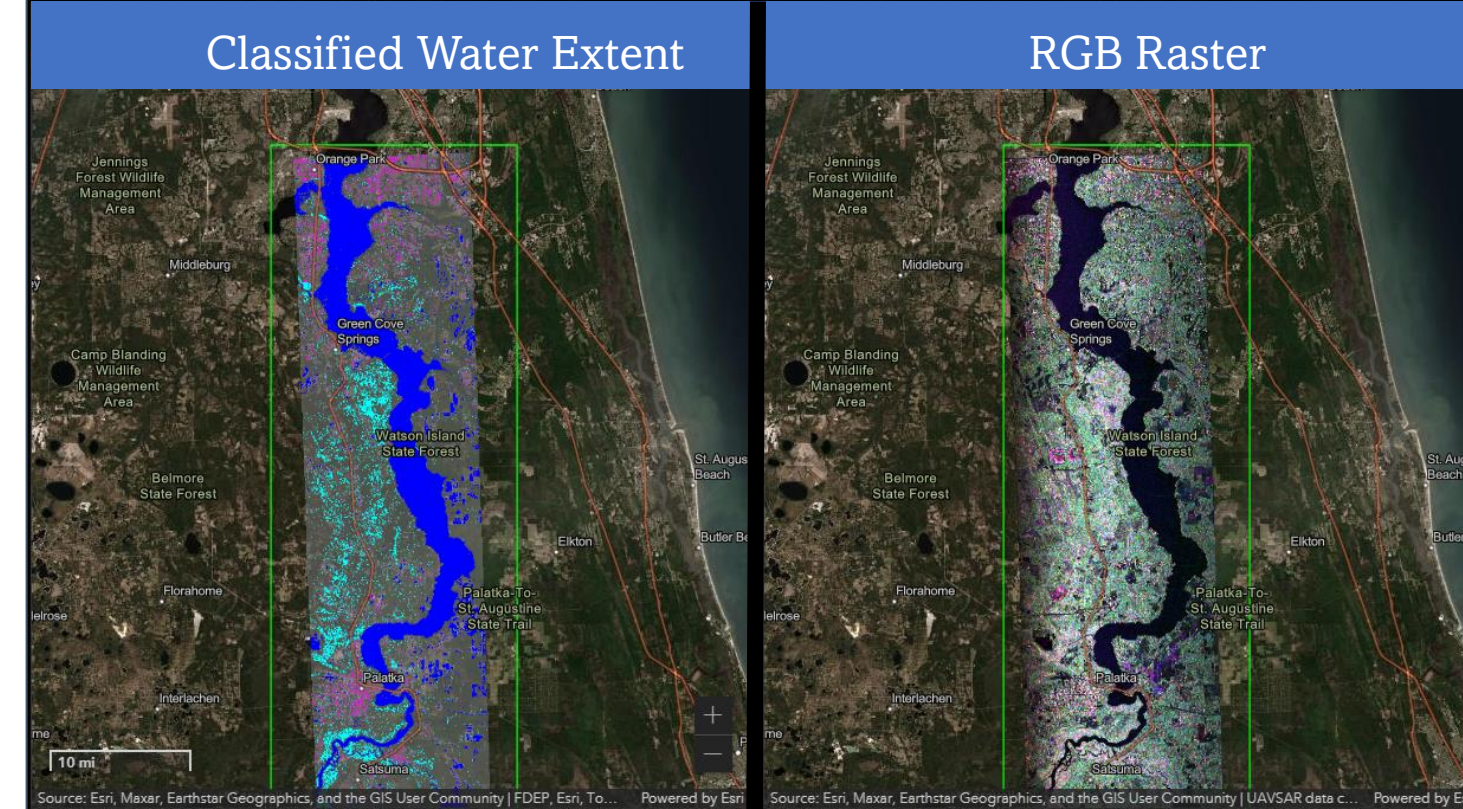
#### Color Infrared Composite



Color Infrared composites were created using the near-infrared, red, and green channels from the MultiSpectral Instrument (MSI) on the European Space Agency's (ESA) Copernicus Sentinel-2 from pre-event (October 18, 2023) and post-event (October 14, 2024), allowing for the ability to see areas impacted from the storm. The near-infrared gives the ability to see through thin clouds. A Color Infrared composite depicts healthy vegetation as red, water as blue. Some minor atmospheric corrections have occurred.

Contains modified Copernicus Sentinel data (2024) processed by ESA.

#### Water Extent & RGB Rasters



The NASA JPL UAVSAR collected synthetic aperture radar imagery over parts of central Florida from Oct 11-14 following Hurricane Milton. The UAVSAR images can be used to identify flooding, especially in vegetated areas and under tree canopy. The team produced "quicklook" images and a derived water extent product. Within the classified water extent product (left) the blue color = open water and flat surfaces (e.g., roads), the cyan color = inundated vegetation, and the pink color = urban areas that may be inundated (low confidence). Within the RGB raster product (right) the green color = vegetated areas, the pink color = inundated forest, fields, and urban areas, and the black color = open water and smooth surfaces (roads, bare ground).

UAVSAR data courtesy of NASA/JPL-Caltech.