The NASA Disasters Response Coordination System's (DRCS) Response to the 2024 Hurricane Season

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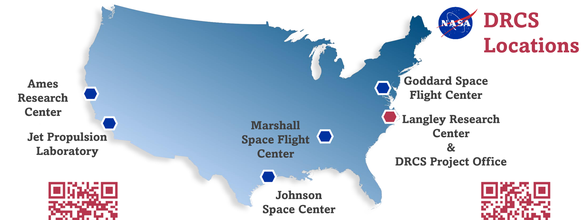
ABSTRACT

The National Aeronautics and Space Administration (NASA) Disasters Response Coordination System (DRCS) leverages the best available science and expertise to aid federal, state, local, and non-governmental organization (NGO) partners in addressing identified needs during a disaster response. During the 2024 hurricane season, the DRCS activated for seven hurricanes/tropical storms, providing openly available geospatial data through NASA's Disasters Mapping Portal. Hurricanes Helene and Milton were major hurricanes that impacted the southeastern United States within weeks of one another. Impacts from Helene and Milton to the region included inland flooding, record coastal storm surge, over a thousand landslides, and regional power and telecommunications outages. In response to Helene and Milton, DRCS provided actionable information and products to stakeholders, including Synthetic Aperture Radar (SAR) analysis for landslide and flood detection, Black Marble nighttime lights products for assessing power outages, and Normalized Difference Vegetation Index (NDVI) analysis for post-event vegetation change detection. NASA deployed the Uninhibited Aerial Vehicle SAR (UAVSAR) instrument to collect data on flood extent, filling spatial, spectral, and temporal gaps in inundation data. Additionally, astronauts aboard the International Space Station (ISS) collected hand-held digital camera photography along the paths of Hurricane Helene and Milton to aid in response efforts. Here, we summarize the DRCS responses to Helene and Milton, in particular highlighting the information and products that were provided by the DRCS and how they were utilized by partners to address immediate response needs.

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.



disasters.nasa.gov/response

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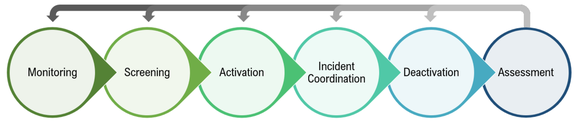
DRCS Activation Lifecvcle



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).

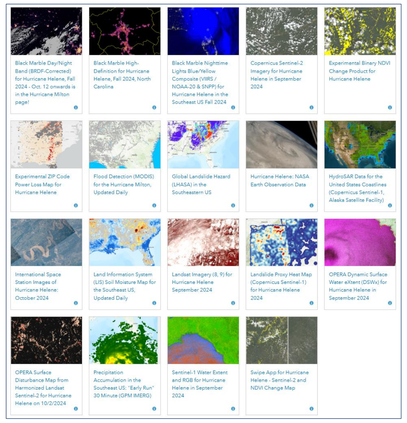
The DRCS provided 67 products through the seven event galleries to enhance situational awareness and inform response efforts relating to applications such as:

- 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

Insights into the types of products produced for two recent responses →

HURRICANE HELENE

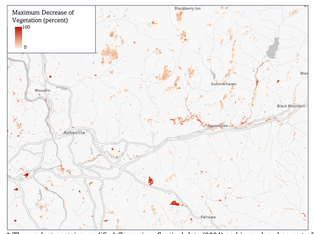
Hurricane Helene caused significant flooding, landslides, power outages, and damage across Florida, Georgia, South Carolina, North Carolina, Virginia, and Tennessee, impacting a land area over 150,000 square miles. The DRCS collaborated directly with FEMA, state emergency management agencies from Florida, 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 September 24 through October 24.



Product gallery for the DRCS Hurricane Helene response.

Hurricane Helene Story Map

Vegetation Disturbance

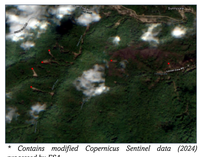


The Advanced Rapid Imaging and Analysis (ARIA) and Observational Products for End-Users from Remote Sensing Analysis (OPERA) teams at NASA's Jet Propulsion Laboratory and California Institute of Technology derived the disturbance maps using the OPERA Disturbance Alert from Harmonized Landsat Sentinel-2*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

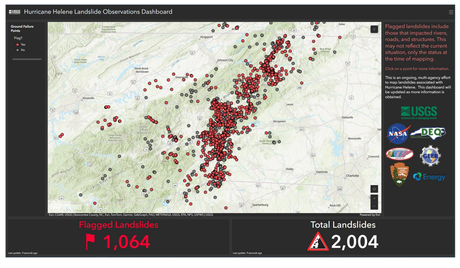
* The product contains modified Copernicus Sentinel data (2024) and is produced as part of the OPERA project, which is funded by NASA to address remote sensing needs identified by the Satellite Needs Working Group. Managed by JPL, OPERA funds and manages the DIST-ALERT-HLS product developed and produced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

Landslide Points

The NASA Goddard Space Flight Center (GSFC) 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 (seen below). The image to the right is a Sentinel-2* scene from October 7 used to map landslides for this effort.

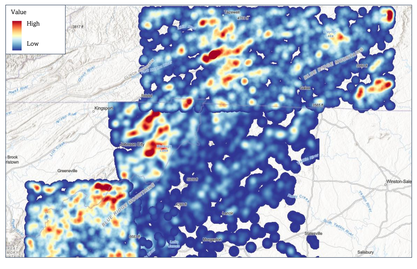


** Contains modified Copernicus Sentinel data (2024) processed by ESA*



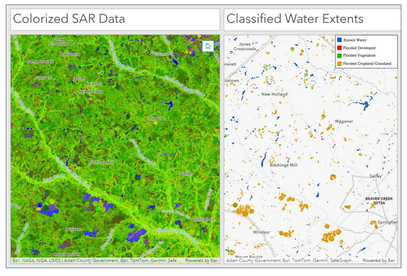
Landslide Density

A Sentinel-1* SAR backscatter change approach developed in Google Earth Engine (Handwerger et al., 2022) detected areas with high landslide density. This heatmap shows the density of possible land surface disturbances (landslides) as observed on September 28, compared to a pre-incident baseline. The red and yellow areas indicate potential zones of dense landsliding. This map should be used as a guidance to identify areas likely affected by landslides. This is a rapid response product created by the NASA GSFC Landslides Team, with no form of manual correction performed.



* Contains modified Copernicus Sentinel data (2024) processed by ESA. Created by NASA GSFC Landslides Team. Handwerger AL, Huang M-H, Jones SY, Amatya P, Kerner HR, Kirschbaum DB. 2022. Generating landslide density heatmaps for rapid detection using open-access satellite radar data in Google Earth Engine. Nat. Hazards Earth Syst. Sci. Copernicus Publications, 22(3): 753–773. https://doi.org/10.5194/nhess-22-753-2022.

RGB Composites & Surface Water Extent



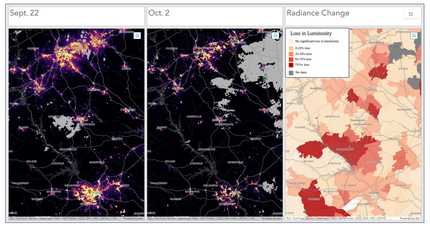
The Alaska Satellite Facility developed false color Red, Green, Blue (RGB) and Radiometrically Terrain-Corrected (RTC) composites and surface water extent products of the Sentinel-1A/B* SAR instrument, which assigns the co- and cross-polarization information to a channel in the composite. When used to support a flooding event, areas in blue denote water present at the time of the satellite overpass. Blue areas have low returns in both VV and VH polarizations (smooth surfaces such as calm water, but also frozen/crusted soil or dry sand), Green areas have high returns in VH (volume scatterers such as vegetation or some types of snow/ice), and red areas have relatively high VV returns and relatively low VH returns (such as urban or sparsely vegetated areas).

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

Nighttime Light Radiance Change

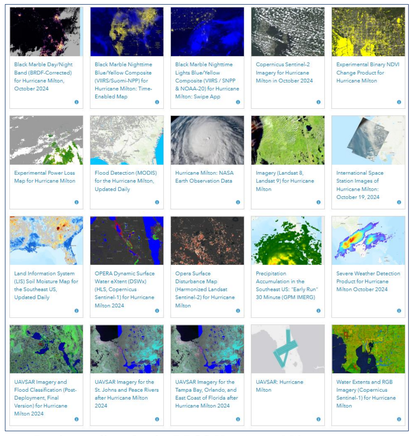
Nighttime lights imagery is often used for identifying nighttime lights from cities, fires, boats, and other phenomena. At its highest resolution, this visualization represents the underlying data scaled to a resolution of 500m per pixel at the equator. These data were created by the Black Marble Science Team* at NASA GSFC and were published daily from September 18 throughout the activation. The maps on the right compare pre-incident nighttime lights as seen on September 22 (left) with a post-incident scene from October 2 (center). DRCS created an experimental radiance change map aggregated by zipcode (right) to localize possible power outages and impacts. The radiance change product is under development. Currently it visualizes the percent change in luminosity between the August baseline and October 2, aggregated at the zip code level. Red areas experienced the most loss in luminosity, while gray indicates no date or cloud coverage.



** Román MO, Stokes EC, Shrestha R, Wang Z, Schultz L, Carlo EA, Sun Q, Bell J, Molthan A, Kalb V, Ji C. Satellite-based assessment of electricity restoration efforts in Puerto Rico after Hurricane Maria. PloS one. 2019 Jun 28;14(6):e0218883. and Román MO, Wang Z, Sun Q, Kalb V, Miller SD, Molthan A, Schultz L, Bell J, Stokes EC, Pandey B, Seto KC. NASA's Black Marble nighttime lights product suite. Remote Sensing of Environment. 2018 Jun 1;210:113-43.*

HURRICANE MILTON

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.



Product gallery for the DRCS Hurricane Milton response.

Hurricane Milton Story Map:

Astronaut Photography

International Space Station (ISS) crew handheld photography of Bradenton, Florida taken October 19, 2024. Photography collected by the ISS crew is georeferenced and shared for optical flood mapping applications.

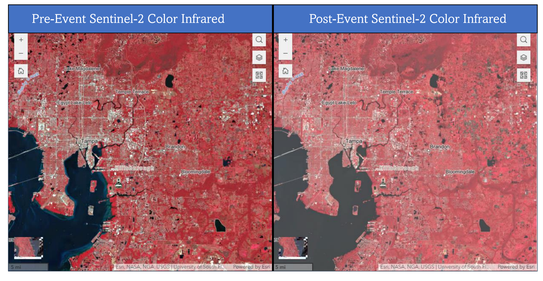
* Image courtesy of the Earth Science and Remote Sensing Unit, NASA Johnson Space Center

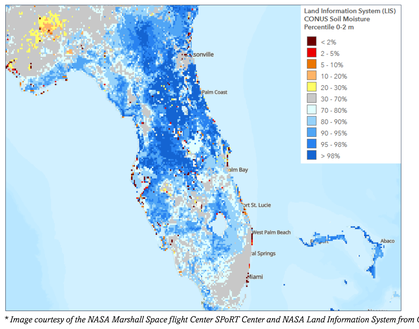
Color Infrared Composite

The Color Infrared composite was 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





Soil Moisture Percentiles

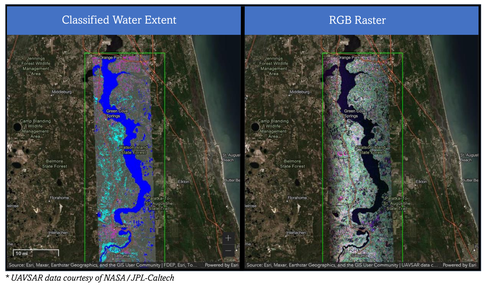
The NASA Land Information System (LIS) is a high-performance land surface modeling and data assimilation system used to characterize land surface states and fluxes by integrating satellite-derived datasets, ground-based observations, and model re-analyses. The NASA Short-term Prediction Research and 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. A unique feature of SPoRT-LIS is the incorporation of daily, real-time satellite retrievals of Visible Infrared Imaging Radiometer Suite (VIIRS) Green Vegetation Fraction since 2012, which results in more representative evapotranspiration and ultimately soil moisture estimates than using a fixed seasonal depiction of vegetation in the model. 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.*

Water Extent & RGB Rasters

The NASA Jet Propulsion Laboratory UAVSAR collected synthetic aperture radar imagery* over parts of central Florida from October 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*