NASA Earth Science Disasters Program

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On behalf
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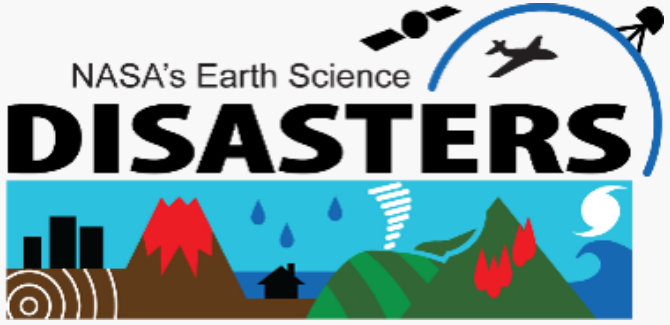
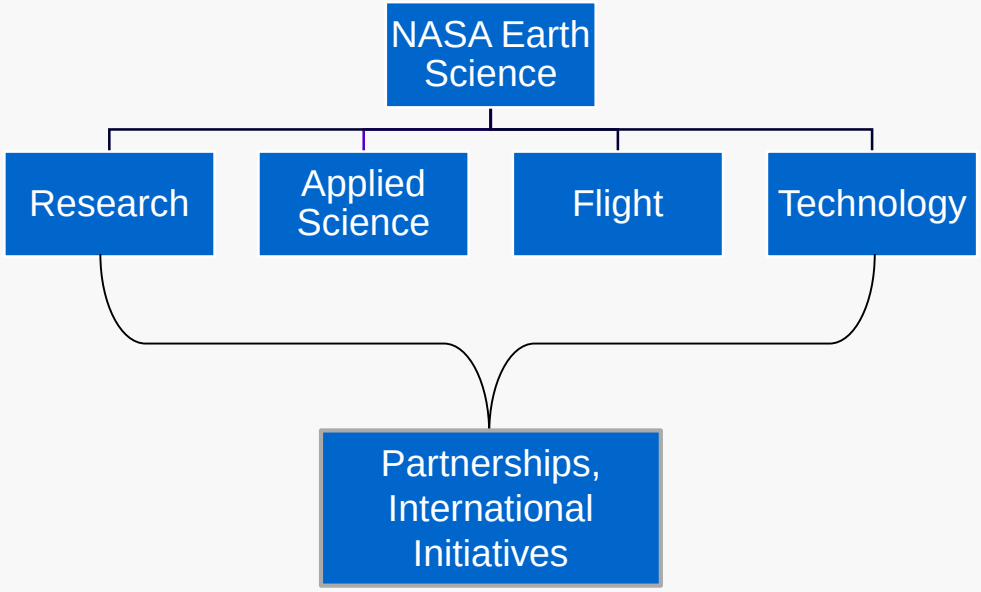
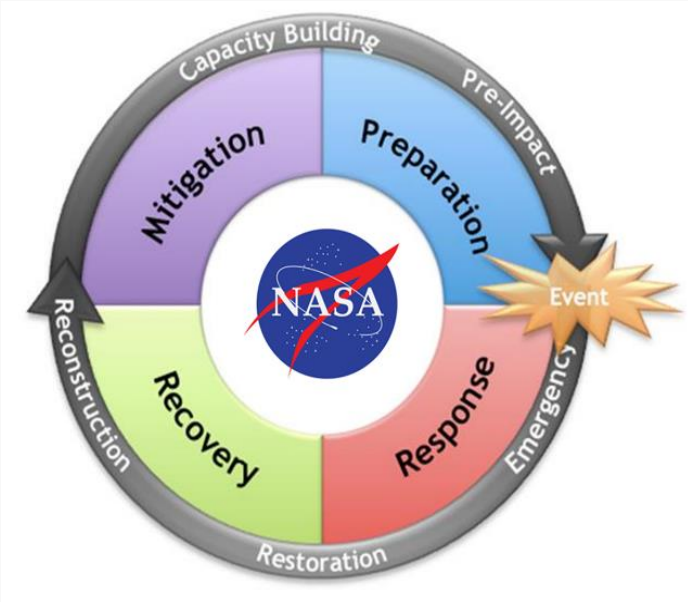
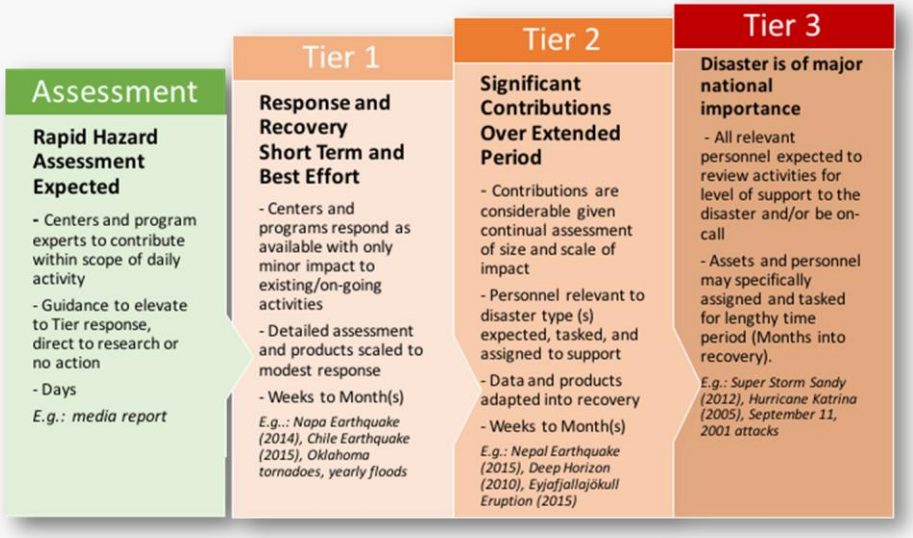


What is the NASA Earth Science Disasters Program?





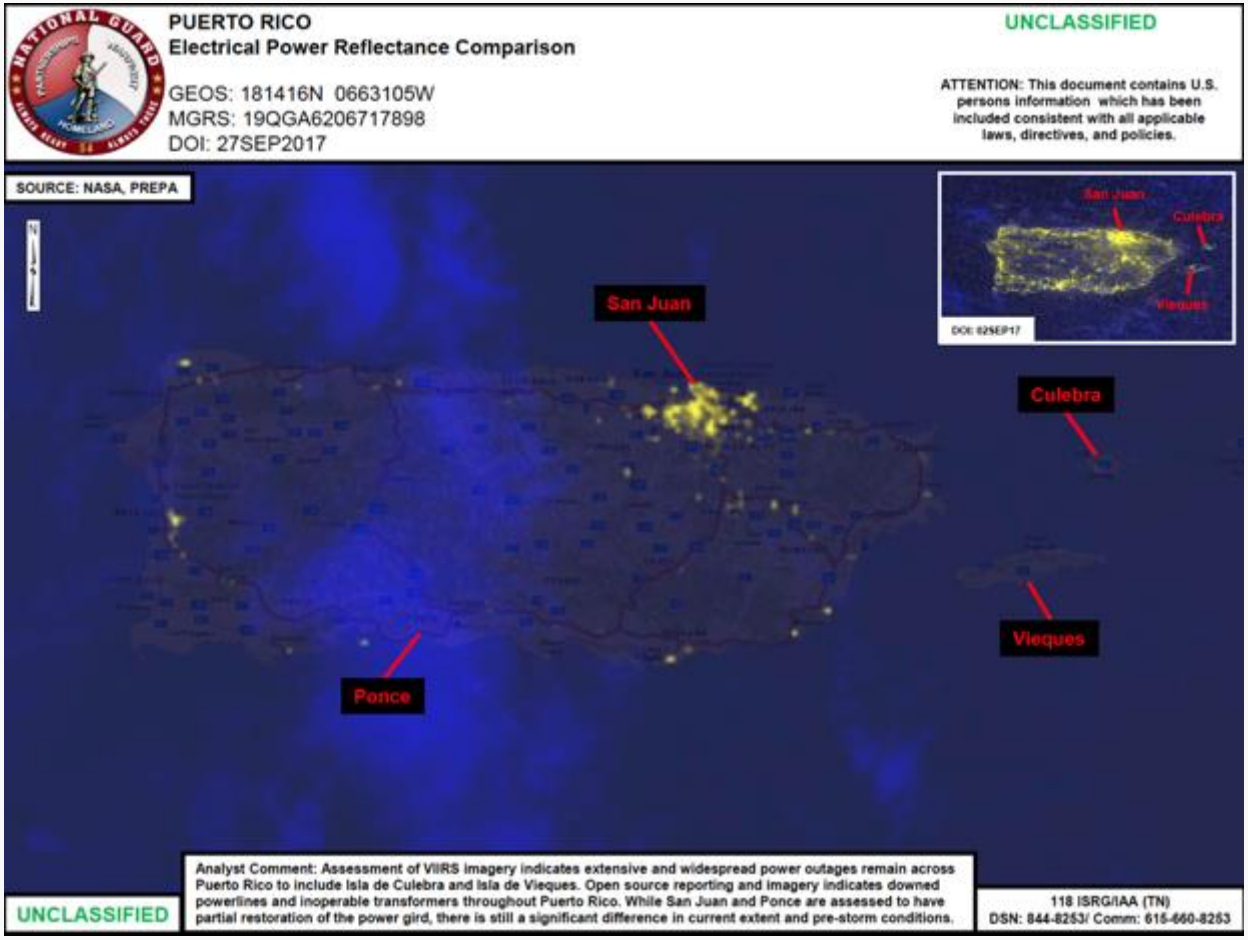
- *Utilizing the various NASA centers and their resources, a robust response program has been assembled to respond to various disasters worldwide*
  - *Meteorological/Hydrological*
  - *Geophysical*



Response for Harvey, Irma, and Maria and Two Earthquakes

- ***The Challenge*:**
  - **Hurricanes Harvey, Irma, and Maria have presented unique challenges, needs, and opportunities for NASA's Earth Science Disasters Team to engage with end users.**
- Earth Science Disaster Response Team members have used pre-planning and execution of playbooks to provide continued support from late August through early October
  - Team activities focused on uniform coordination with end-user partners:
    - FEMA, National Guard Bureau, USAID Office of Federal Disaster Assistance, USGS/HDDS for recent hurricanes and coastal flooding events
    - CENAPRED for Mexico Quakes
- Event leads at MSFC (Hurricanes) and JPL (Earthquakes) worked with other Centers, NASA PIs, and other partners to coordinate response efforts.
  - *Team leads participated in multiple daily interagency calls 24/7, provided support to end users via phone and email, and supported by other scientists and PAO specialists to publicize activities, share science stories, and other outcomes.*
- ***The Result:***
  - ***Focused coordination with FEMA and the National Guard led to extensive use of NASA-provided information in response and recovery activities.***

Pinpointing Where Lights Went Out in Puerto Rico



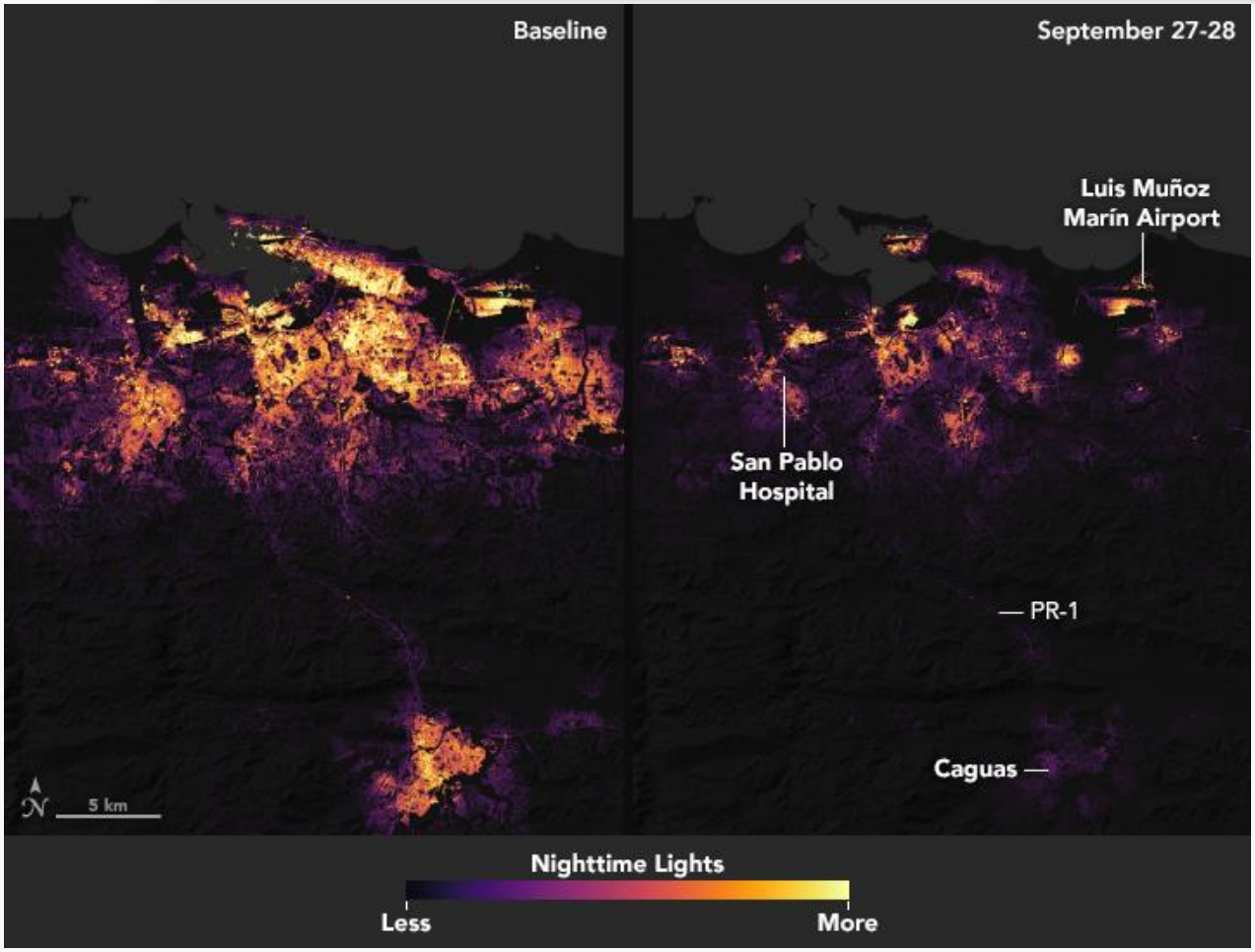
(Sources: U.S. National Guard Bureau Analysts/S-NPP VIIRS)

The Solution: Routine distribution of pre-event (upper right) and post-event (center) nighttime scenes to the US National Guard Bureau team members ***assisted in their detailed analysis of power conditions and response activities***.

- **The Challenge:** ***End-users highly value quantitative analyses,*** along with rapid assessments that can improve interpretation of outage conditions. Satellite products are more useful when science teams, and affiliated members, assist with guidance and interpretation.

- **Unique Features:** NASA's Black Marble standard products combine "night vision" imagery with thermal infrared data; allowing for easy-to-interpret false color composites. Reduction of aerosols, air-glow, and moonlight contamination dramatically improves temporal coverage (from monthly- to daily updates.)

Pinpointing Where Lights Went Out in Puerto Rico

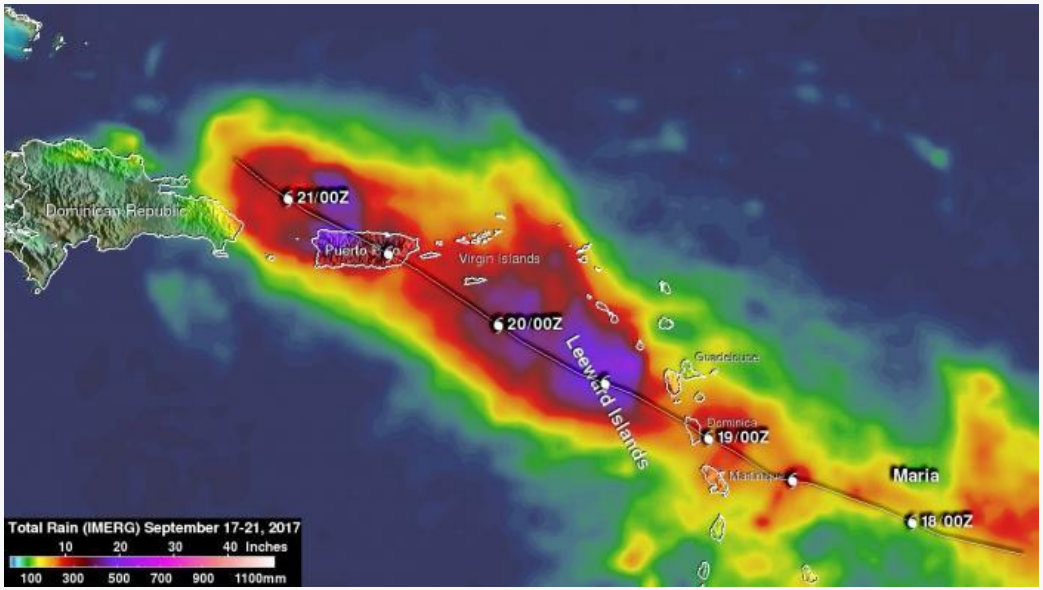


- **The Challenge:** US Govt and PR officials, construction and utility crews, transport authorities, health providers, and relief organizations needed to know the extent of power outages in PR to assess human and social perils, extent of infrastructure losses, and logistical priorities.

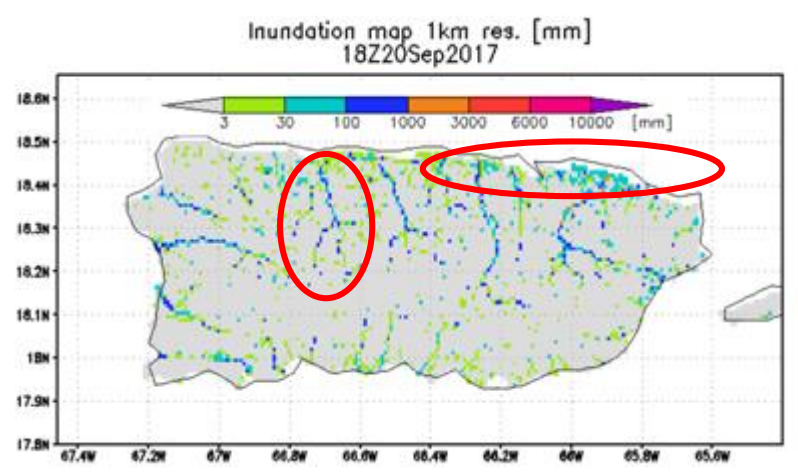
- **Unique Features:** NASA's Black Marble High Definition (HD) products ***enable first-ever monitoring of affected areas at neighborhood scales (~30m)***.

The Solution: To make the Suomi-NPP data more useful to first responders, NASA scientists are scaling quality-controlled VIIRS Day/Night Band observations onto a base map that shows the precise locations of streets and buildings.

Hurricane Maria's Torrential Rainfall Measured by NASA's Integrated Multi-satellite Retrievals for GPM (IMERG)



Total Rainfall (IMERG) Sept 17-21, 2017



(GFMS) Hurricane Maria Impacts Sept 20, 2017; 200-400 mm water depth

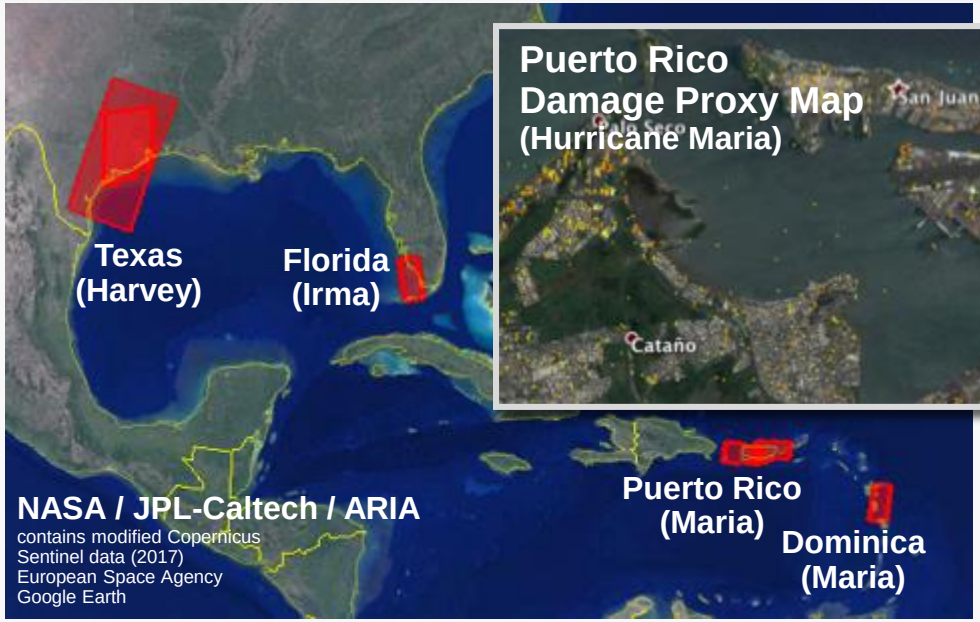
Guajataca Dam Breach

Cataño, PR

- NASA's Integrated Multi-satellite Retrievals for the Global Precipitation Mission (IMERG) were used to estimate the total amount of rain that Hurricane Maria dropped from September 17 to early September 21, 2017.
- During that period Maria dropped heavy rain in the Leeward Islands, Virgin Islands and Puerto Rico (PR).
- IMERG rainfall estimates indicated that more than 20 inches (512 mm) of rain fell over large swaths of PR.
- GPM rainfall accumulation products are provided routinely via R&A activities within SPoRT and were used to monitor rainfall amounts after the San Juan WSR-88D Doppler radar failed during Hurricane Maria.
- The International Red Cross used data from the UMD Global Flood Mapping System (GFMS) to determine potential flooding due to Hurricane Maria for parts of the southeast, northeast, and northern coasts of PR.

Response Support for Three Hurricanes

Satellite SAR made an early flood map of Texas

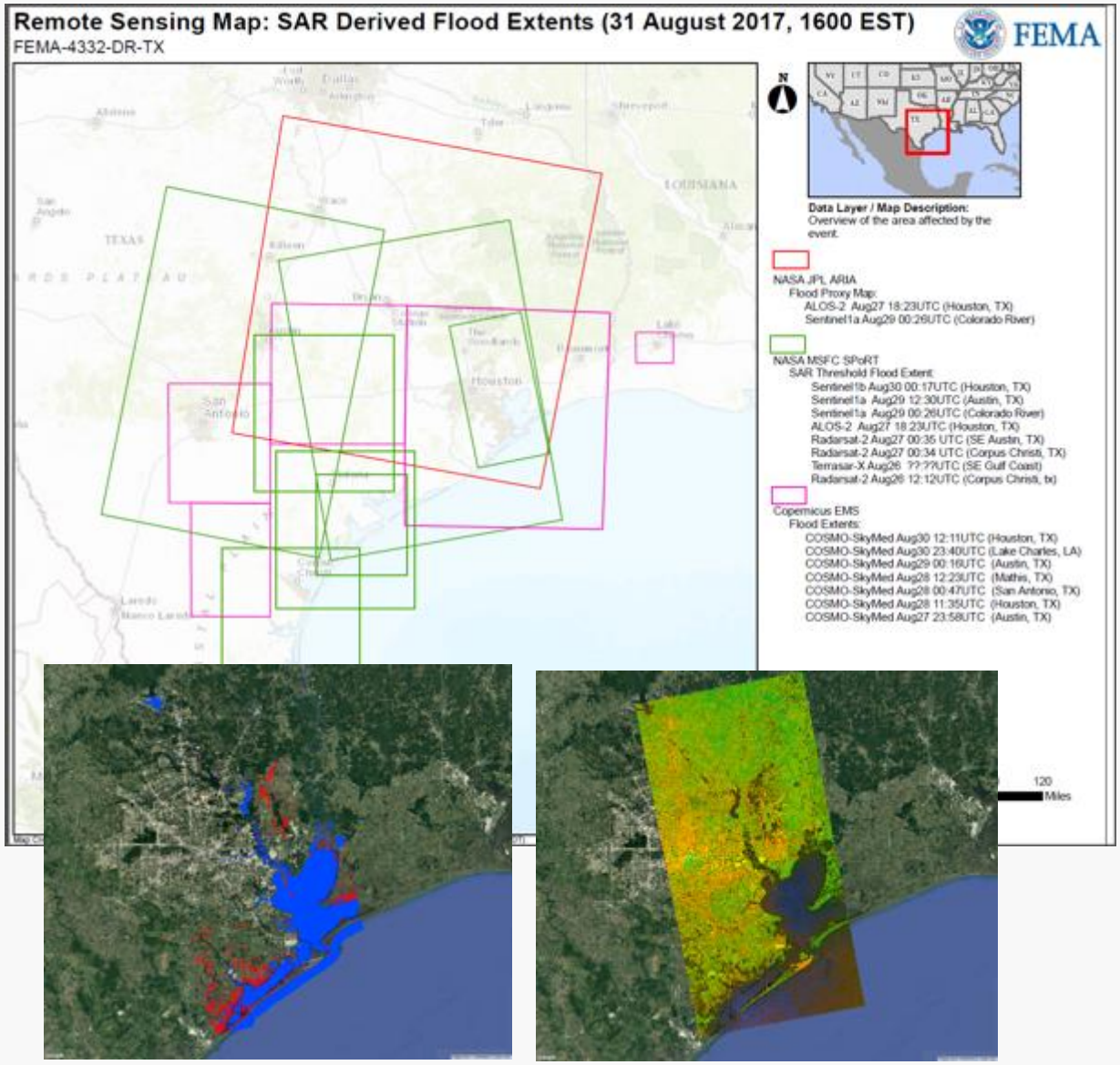


ARIA flood and damage maps for Hurricane Harvey, Irma, and Maria

FEMA combined DPM data with other information to estimate damage impacts and target response efforts

- NASA's ARIA team generated and delivered flood and damage proxy maps using satellite SAR imagery.
- ARIA provided a flood map from SAR data on 28 August, using data acquired on on 27 August by the Japan Aerospace Exploration Agency's ALOS-2 satellite.
- The flood map, delivered to FEMA and the state of Texas, covered a wide area including Houston (350 km x 350 km) and provided a synoptic cloud-free view, when Civil Air Patrol was limited by weather conditions, and no satellite optical sensors were able to image the area due to lingering clouds of Hurricane Harvey.
- A damage proxy map of Puerto Rico devastated by Hurricane Maria was generated using SAR data from the Copernicus Sentinel-1 satellites (operated by the European Space Agency) acquired on 21 September and delivered on 22 September to FEMA.
- FEMA created a damage density map derived from the ARIA damage proxy map and multiple, other data sources and **used DPM information to estimate damage and guide response and recovery activities**

Leveraging Broader SAR Collaborations to Support FEMA

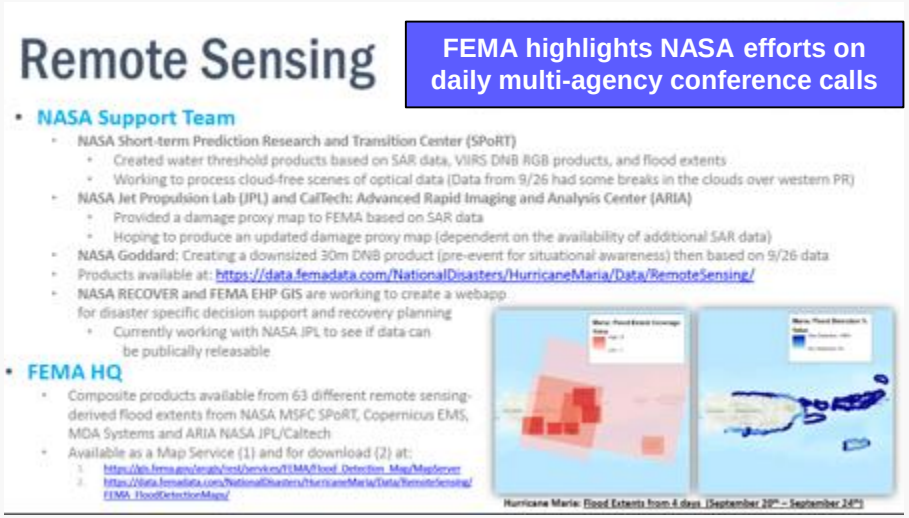


Examples of Copernicus Sentinel 1 (processed by ASF) products used during Hurricane Harvey by end users

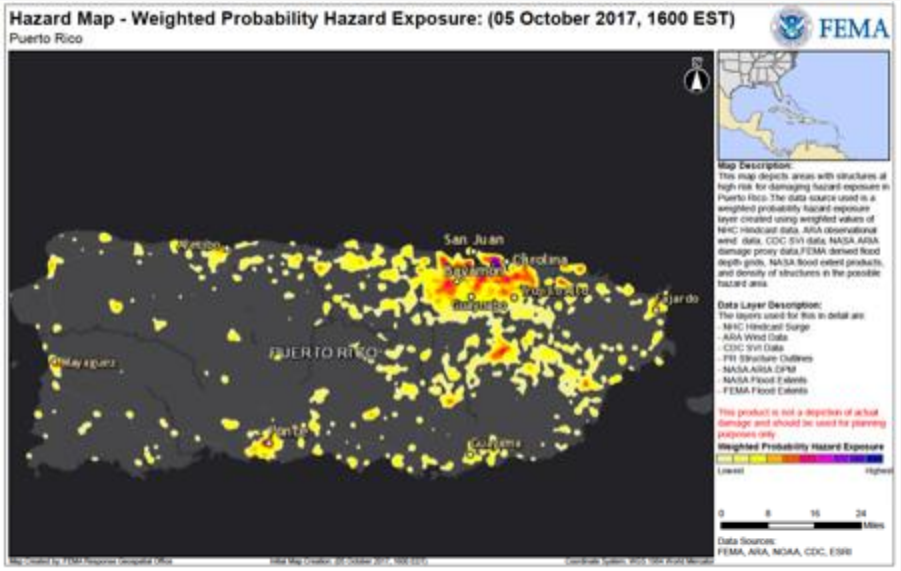
- **The Challenge: *Responding partners need to synthesize information across a large number of different SAR and other satellite platforms***
- Earth Science Disasters Team members have focused on collaborative “Tiger Team” approaches to bring together SAR expertise in support of disaster response events.
- Collaborations with the Alaska Satellite Facility (ASF) and other team members on SAR processing and knowledge helped to generate products from Charter and Copernicus Sentinel-1 data, assisting with flood mapping for government partners.

Team Success Stories in Partnerships with End Users

- **Partners at FEMA used SAR-based flood analysis to help verify and validate modeling simulations:**
  - *"We focused on [the Aransas area] and [flood products] seemed to match well with our floodplain boundaries."*
- **Damage proxy information combines with other data to strategize response and recovery:**
  - *"We used the DPM to refine initial impacts of damage and help with targeting of response efforts, and FEMA will work on ground-truth to validate and focus on including this into future production workflows."*
- **Partners in the National Guard appreciated access to Black Marble products for analyzing nighttime lights:**
  - *"…The accuracy and quality of the product was upgraded significantly by a updated product recently [received] from NASA."*

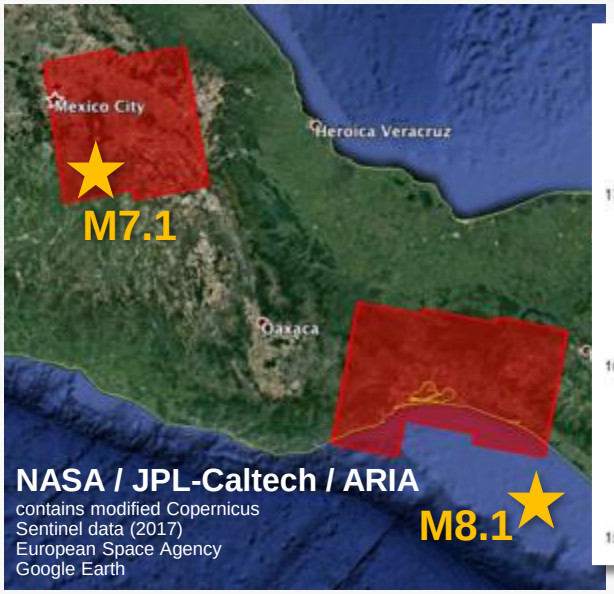


Event leads participated in FEMA remote sensing and geospatial telecons (above) which highlighted significant contributions from NASA partners.

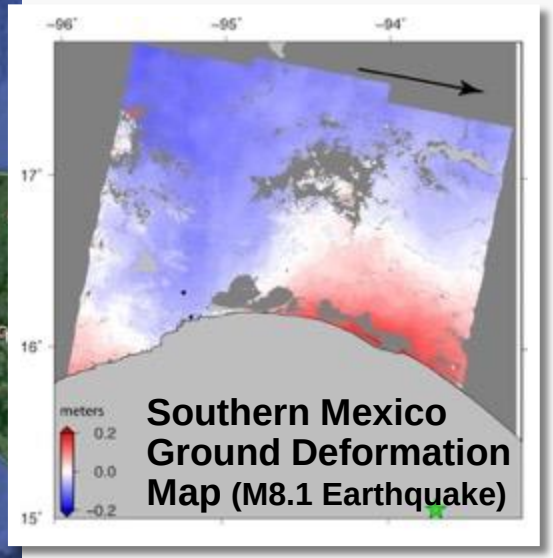


Example of NASA JPL/ARIA DPM and NASA flood mapping combined with other FEMA geospatial data to produce internal value-added product used to guide response and recovery efforts including targeting of CAP flights.

Response Support for Two Earthquakes



ARIA damage maps and ground deformation map for the M8.1 and M7.1 earthquakes in Mexico



Map of ground deformation caused by the M8.1 Chiapas earthquake

- NASA's ARIA team generated damage proxy maps and ground deformation map using satellite SAR imagery.
- A magnitude 8.1 earthquake (the strongest in more than a century in Mexico) hit Southern Mexico on 7 September, causing wide spread building damage and 98 casualties.
- A ground deformation map and damage proxy map of the M8.1 event was generated using the Sentinel-1 SAR data from the Copernicus Sentinel-1 satellites (operated by the European Space Agency) and were delivered to the Geotechnical Extreme Events Reconnaissance (GEER) Association.
- Twelve days after the M8.1 earthquake, on 19 September, a magnitude 7.1 earthquake devastated central Mexico, including Mexico City, causing 366 deaths and injuring more than 6,000.
- A damage proxy map was made from the Sentinel-1 SAR data acquired on 20 September (6-1/2 hours after the quake) and was delivered to the Mexican Space Agency (AEM) and Mexico National Center for Prevention of Disasters (CENAPRED) on Sept. 20 – ***a record within-a-day delivery***