Earth Observations from Global to Regional Scales for Disaster Risk Reduction and Response

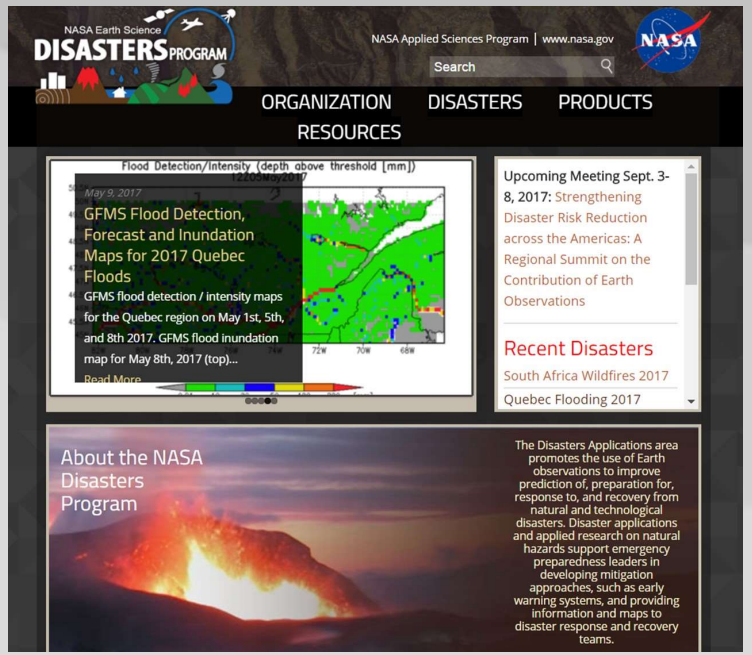
Dr. David Green
Disaster Program Manager
Science Mission Directorate
Earth Science Division

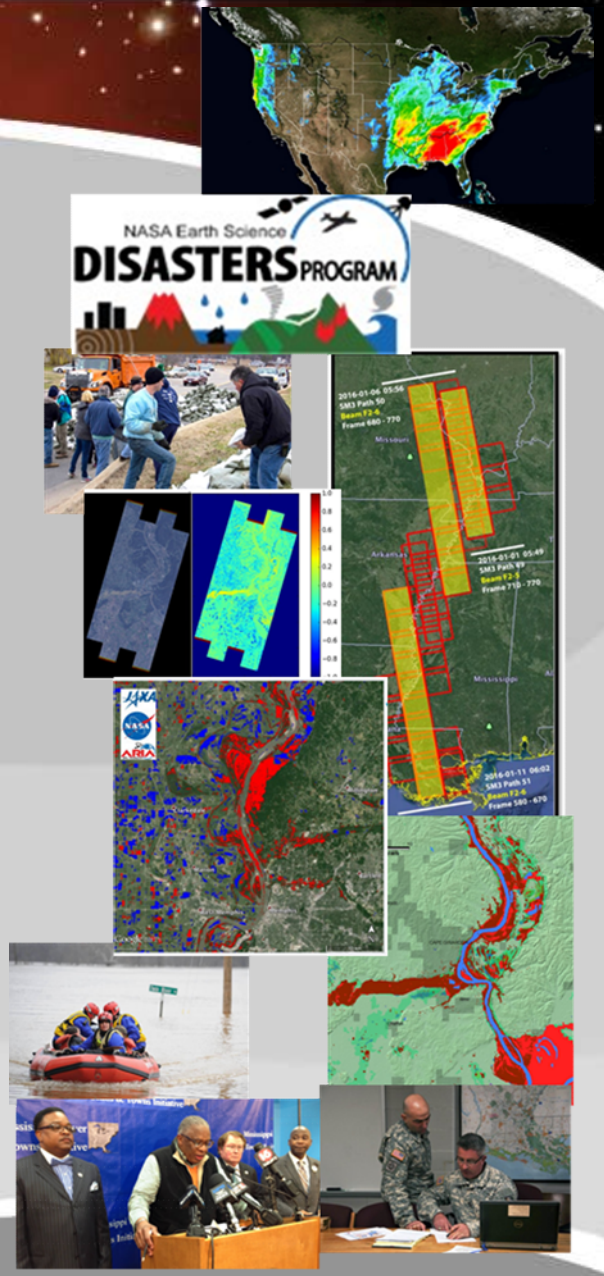
Global Flood Partnership 6/27/2017

Overview

https://disasters.nasa.gov/floods

- *Risk Reduction and Response*
  - Global Framework and Partnerships
  - Workflows: Monitoring, Outlooks, Extent, Duration, Impacts
  - Engagement





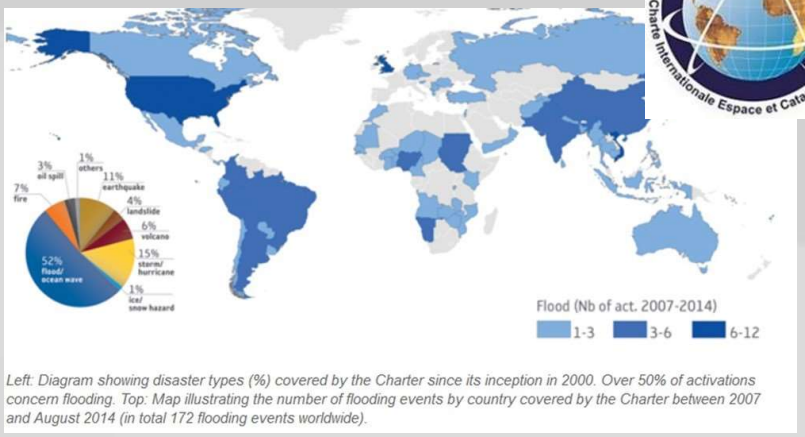
https://disasters.nasa.gov/

International Coordination and Data Sharing

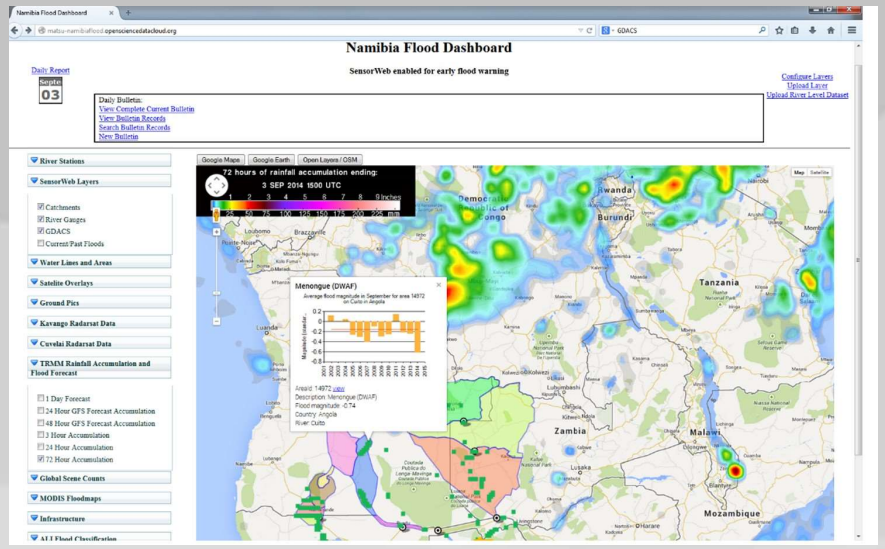
Group on Earth Observations - Flood Task:

Supporting access to a unified system of space data acquisition and delivery, models and mapping to support those affected by natural or man-made disasters

GFP: better link to users
From hazards to impacts



Left: Diagram showing disaster types (%) covered by the Charter since its inception in 2000. Over 50% of activations concern flooding. Top: Map illustrating the number of flooding events by country covered by the Charter between 2007 and August 2014 (in total 172 flooding events worldwide).



AmeriGEOSS – The Americas
Group on Earth Observing System of Systems

Strengthening Disaster Risk Reduction across the Americas: A Regional Summit on the Contribution of Earth Observations

September 3rd - 8th, 2017

Buenos Aires, Argentina *

Version en español

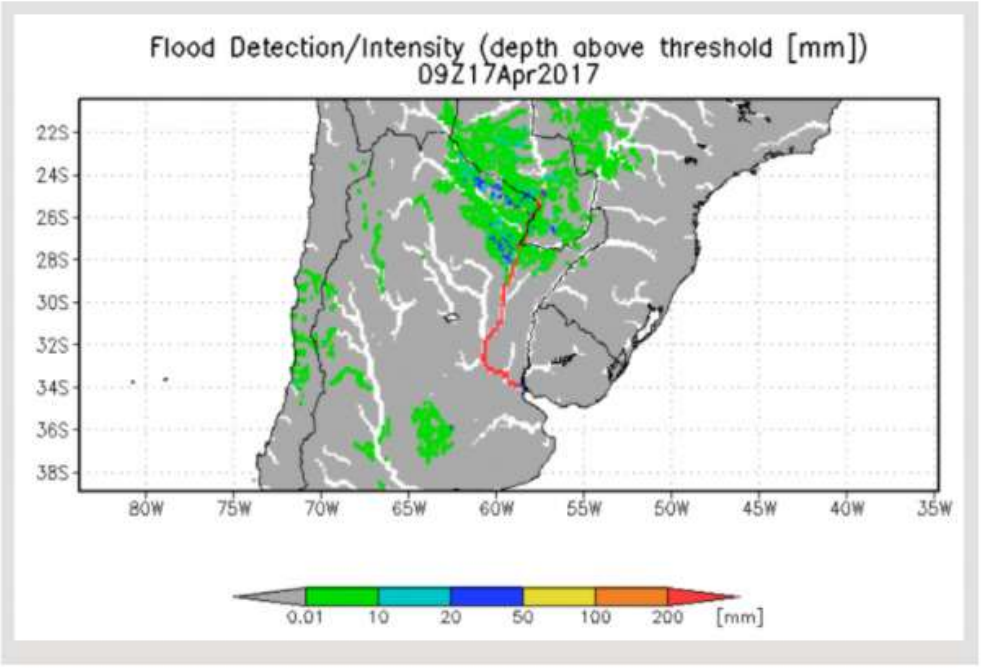
The Disaster Risk Reduction (DRR) Across the Americas Summit will provide the unique opportunity for needed joint dialogue and work planning between representatives of the scientific earth observation (EO) and DRR community, including stakeholders in regional preparedness and planning, disaster mitigation, emergency response, and recovery. Using the UNISDR Sendai Framework as an impetus, which calls for an increased role for science

Click here to sign up for more information about the summit.

CEOS

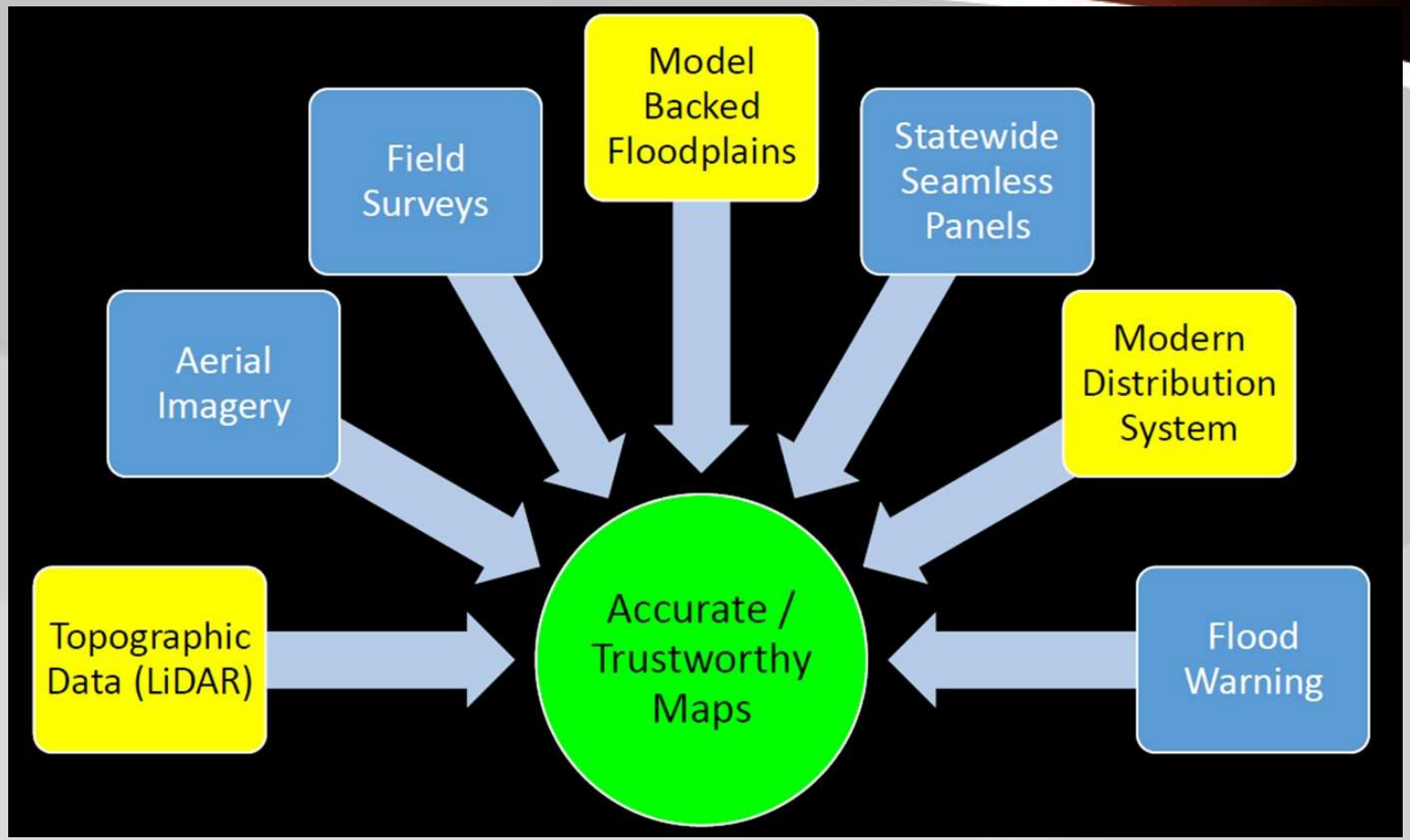
GEO GROUP ON EARTH OBSERVATIONS

Overview of northern Argentina floods on April 17th 2017



https://disasters.nasa.gov/argentina-summit-2017

Risk Reduction – Moving Global to Local Exposure, Vulnerability and Impacts



**** J. Dorman, North Carolina Public Safety***

Is there Timely and Relevant Remote Sensing Data and Information?

Limitations for using remote sensing (satellite and airborne) due to

- Routine monitoring vs event characterization
- Discovery and access to data
- Latency and frequency of measurements
- Spatial Resolution
- Variety of data and information products

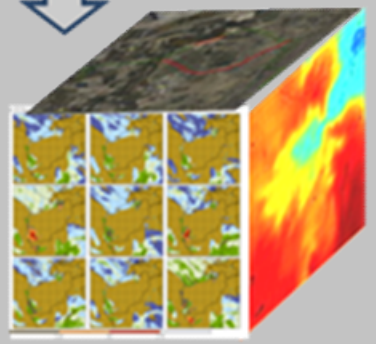
Need to consider if there is a timely flyover, rapid processing and mapping - if yes, data could prove useful.

It all comes down to the questions being asked, knowing what is needed or available, and can it be applied against the time information is needed for action or decisions

Challenge: Moving Data to Modeling to Mapping To Tools for Decision Support

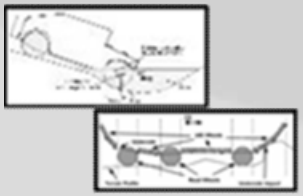
Atmospheric Forcing

Global models run persistently

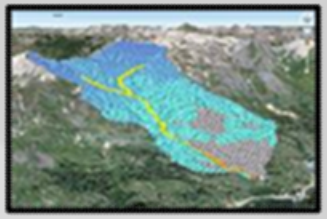


Terrestrial Modeling (e.g. LIS)

Stream Routing (e.g. RAPID)

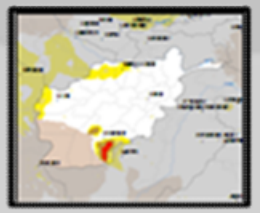


Mobility Analyses



Snow Assessments

Humanitarian Assistance



Drought Vulnerability

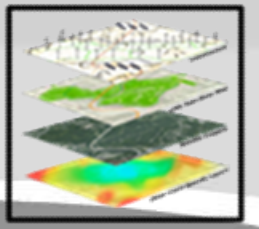
Navigation

Social Issues

Economic Issues

Chemical/Biological/Radiation Hazards

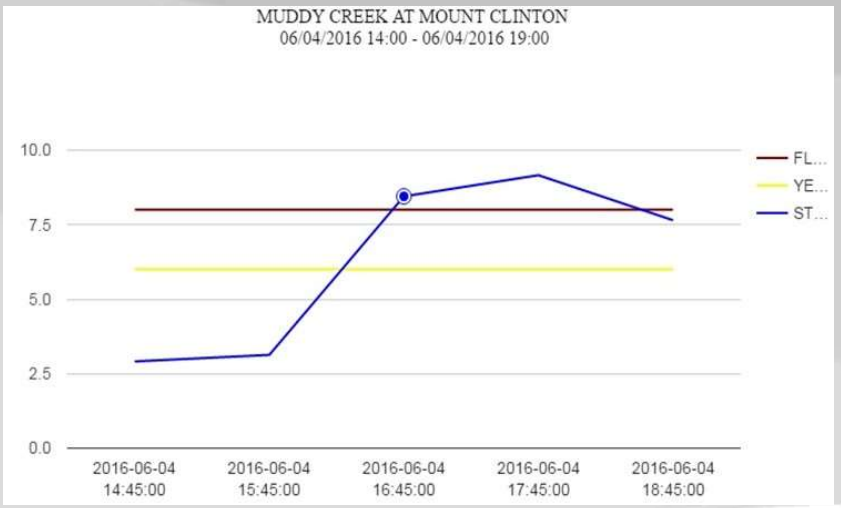
Transportation Networks



Other Layers

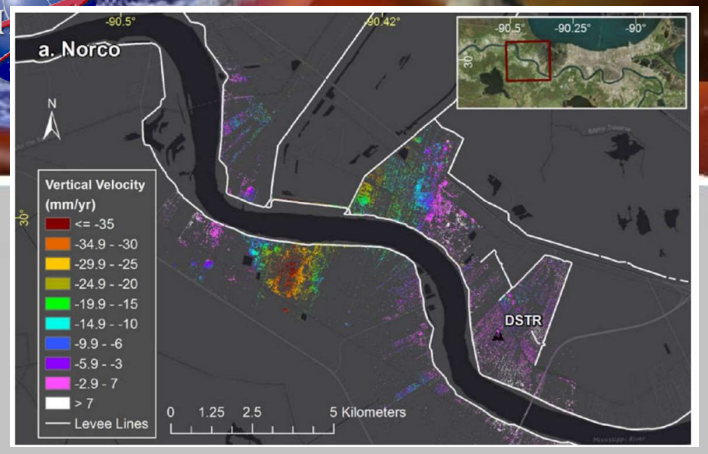
Challenge: Flash Flood Situation is Local and Timely

Heavy rain creates very fast rate of water rise. Important to know the flash flood guidance since most streams are not gauged

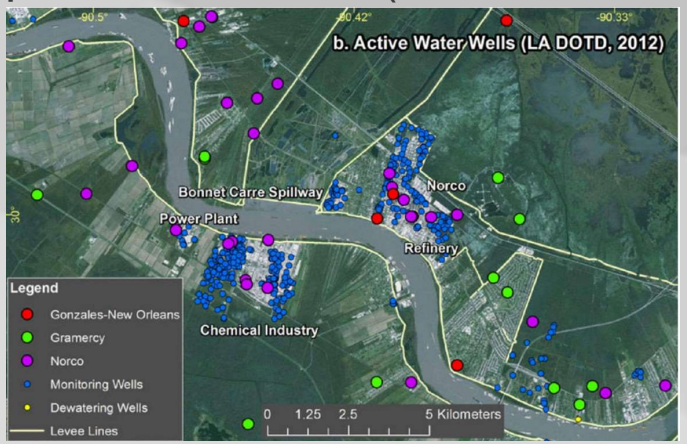


Time	Depth(ft.)
2016-06-04 14:45:00	2.91
2016-06-04 15:45:00	3.13
2016-06-04 16:45:00	8.45
2016-06-04 17:45:00	9.16
2016-06-04 18:45:00	7.65

Challenge
Where the Ground is Sinking.. Subsidence



Subsidence rates in the area of Norco, Louisiana, as well as the flood protection levees (the white lines).

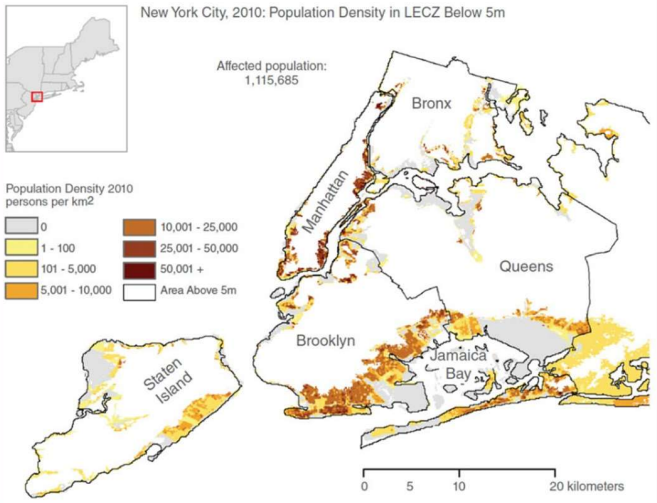


Location of water wells and local industry. The highest subsidence forms a bowl within the industrial site to the south of the river.

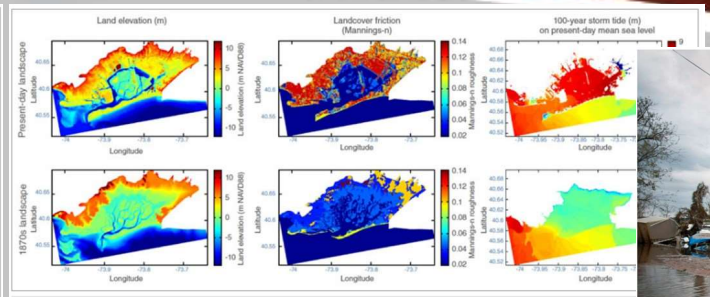
Jefferson Parish, Louisiana, and how much subsidence has occurred in some areas. The measurements combine movement of the ground and structures.

People and Place

Population Density Below 5m



This map of the New York City boroughs and the western edge of Nassau County (right edge of the map) shows the population density in contiguous low-elevation coastal zones below 5 meters above mean sea level. The population density data are based on 100-meter resolution 2010 population data. Lidar elevation data at 1-meter resolution are used to filter for elevation; the map only shows population density data where more than 50 percent of a cell area is below 5 meters in elevation. (Courtesy K. MacManus)



These maps of Jamaica Bay show how long-term changes to the landscape have affected storm tides. The left colu
shows the land elevation for the present day and for the 1870s, before the bay was altered for human purposes.
center column shows the relative friction of the land cover for the present landscape and for the 1870s, measure
the variable "Mannings-n roughness." The third column shows modeled storm tide levels on the present-day and
landscapes, based on present-day mean sea level. (Courtesy P. Orton)

A man slogs through flooded streets as residents clean out their homes in Midland Beach, Staten Island, New York
[illegible] Sandy. (Courtesy N. Dvir, Polaris)

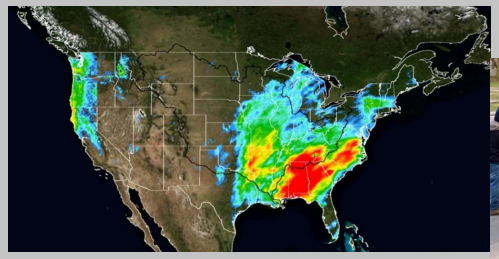
Landscape Change and Storm Surge

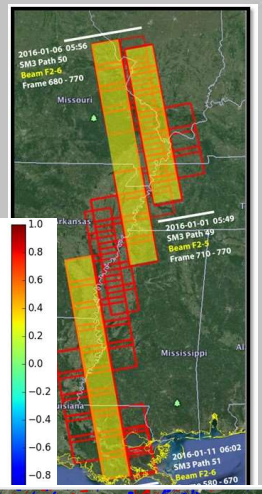
http://sedac.ciesin.columbia.edu/

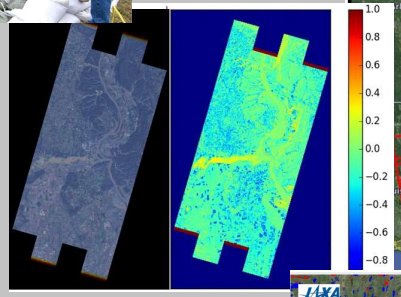
"**The sheer number of people in that situation is challenging to manage**," said Kytt MacManus localized maps from a NASA Socioeconomic Data and Applications Center (SEDAC) data set.

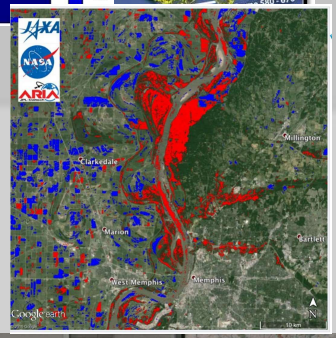
Evacuation would push millions of people over gridlocked roads and through choked bridges and tunnels. "**And many people are unwilling to evacuate**," MacManus said, alluding to research showing about half of people ordered to evacuate refuse to or are reluctant to leave, or face barriers to leaving such as age, illness, or poverty. "**Without making policymakers aware of elevation issues, and making the connection to the number of people impacted, it is hard to get their attention. The data broaden the community that registers on their radar**," MacManus said.

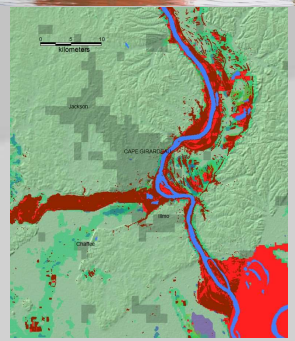
Event Case: Response to Record Flooding Mapping a Disaster from Illinois to Mississippi December 29, 2015 – January 15, 2016











- Consolidated flood and water-index maps
- GIS-capable web-mapping, visualization and decision tools
- Inundation and Damage proxy maps/assessments
- Imagery and interpretive support
- Prioritized, shared, ingested and processed SAR and optical data over areas of interest and disseminated products to stakeholders

Sendai Framework for DRR 2015-2030

United Nations Office for Disaster Risk Reduction

http://www.unisdr.org/we/inform/publications/43291

Disaster risk reduction requires a multi-hazard approach and inclusive risk-informed decision-making based on the open exchange and dissemination of disaggregated data

Priority 1: Understanding disaster risk

To promote and improve dialogue and cooperation among scientific and technological communities, other relevant stakeholders and policymakers in order to facilitate a science-policy interface for effective decision-making in disaster risk management

Global and regional level

To enhance the development and dissemination of science-based methodologies and tools to record and share disaster losses and relevant disaggregated data and statistics, as well as to strengthen disaster risk modelling, assessment, mapping, monitoring and multi-hazard early warning systems;

Targets

AmeriGEOSS – The Americas
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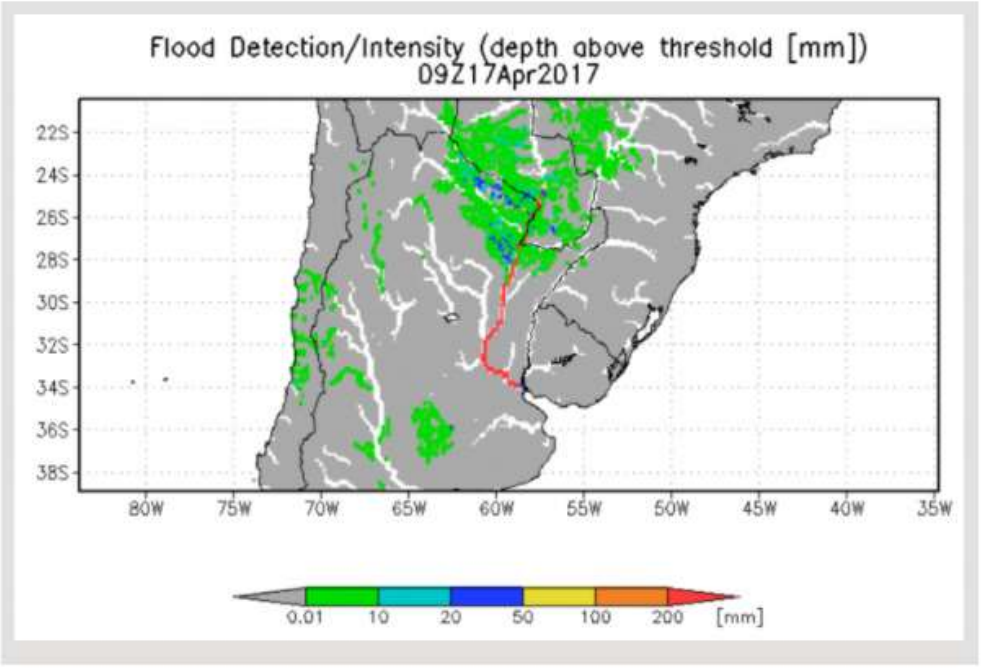


https://disasters.nasa.gov/argentina-summit-2017

DRAFT Working AGENDA

Disaster Risk Reduction Across the Americas:
A Regional Summit on the Contribution of Earth Observations

Sunday September 3rd	Monday September 4	Tuesday September 5th	Wednesday September 6th	Thursday September 7th	Friday September 8th
	Disasters End-to End – Ballroom 9:00 – 13:15	Data to Information 9:00 – 13:15	Information to Decision Support	Scenario Exercise	Planning
	Regional and National Partners in DRR and EO featuring CoNAE, SMN, Ministries, Technical and water institute… fire management… Ballroom 10:00 – 11:30	CEOS	CEOS and AmeriGEOSS; Red Cross Relationship Building	Scenario Exercise	
	Break	Break	Break	Break	Break
	Global to Local and Indigenous Partners in DRR and EO featuring UNISDR and GEO/AmeriGEOSS/CEOS 11:45 – 13:15	CEOS; Data Market – What's available	CEOS and AmeriGEOSS; Mapping and Decision Tools HOT	Scenario Exercise	
	Lunch 13:30 – 14:45 pm	Lunch 12:00 – 2:00 pm	Lunch 12:00 – 2:00 pm	Lunch 12:00 – 2:00 pm	Lunch 12:00 – 2:00 pm
	15:00 PM – 17:00				
	Working Group CEOS; Working Session Ameri-GEOSS; Special Session Hydro-Met Data and Risk Information; Special Session Geo-Hazards Data and Risk Information	CEOS; Emergency Managers and Data Needs Red Cross; OGC Data Processing and distribution, metadata; ESIP Data Quality, reliability and trust What is useful	Case Studies Emergency Managers; Case Studies	Exercise Lessons Captured	
	Break	Break	Break	Break	Break
	17:15- 19:00 PM				
Community Outreach	Working Session CEOS Working Group; Working Session Ameri-GEOSS; Special Session Hydro-Met Data and Risk Information; Special Session Geo-Hazards Data and Risk Information	CEOS; Information Need RedCross; GFP severity; OGC Standard; MC/MG Culture Indigenous Populations	Capacity Building Disasters HydroMet and GeoHazards; Capacity Building SAR tools	After Action Analysis Planning	
Poster Session 17:00 – 21:00	Explore Buenos Aires	Reception	Reception		

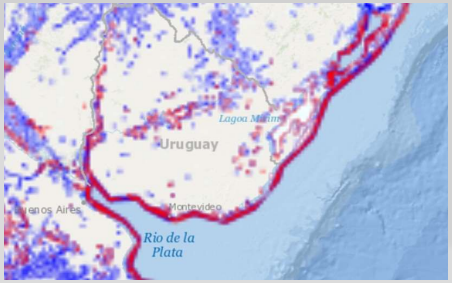
Sessions

Outreach | Plenary | Exercise | Planning

Working - CEOS | Working - GEOSS | Working - Hydro | Working - GEO

Uruguay Floods

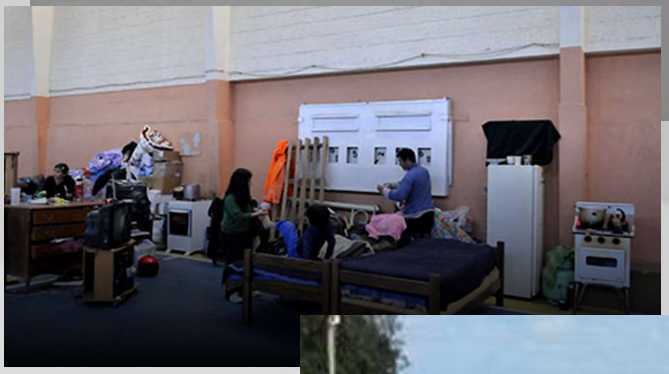
Status update 6/11/17



NASA Earth Science DISASTERS PROGRAM

NASA

Situation June 11, 2017



- Heavy rains caused severe flooding in Uruguay's' Salto Department, Paysandú Department and Bella Unión city of the Artigas department displacing 5585 people (today June 11) with anticipation numbers could reach 10,000 if the upcoming of the waters of the Uruguay River continues, said Fernando Traversa, director of the National Emergency System (SINAE).

- Parts of the neighbouring state of Rio Grande do Sul in Brazil have also been affected by flooding

  - NASA has been in touch with SINAE describing availability of Global Flood Monitoring System Flood Outputs, MODIS Flood Maps, and GPM Rainfall Accumulation Data, and potential SAR products

Ongoing Situation

Uruguay's National Emergency System (SINAE) are visiting affected areas to assess the damage and revise relief efforts. Due to the rainfall occurring in the middle and upper basins of the Uruguay River in southern Brazil, the Uruguay River is forecast to reach its highest level so far between Tuesday 13 and Thursday, June 15

- **Salto will continue to be the most affected Department followed by Paysandú, Artigas and Río Negro (in order of number of people affected)**

- **According to the Salto Grande Mixed Technological Commission (CTM in Spanish), the river flow will stay at high levels at least for the next two weeks. The occurrence of new rainfall events during this period is not discarded. If this happens, the river levels may increase more.**

NASA Response

Northern parts of Uruguay have been under a heavy rain warning since 5/24/17, and authorities expect further rain with flood waters set to continue rising.

- NASA Disasters Program team met face-to-face in a side-bar meeting with Sistema Nacional de Emergencias (SINAE) National Director Fernando Traversa in Mexico at the UNISDR Global Disaster Forum 5/25/17 and reached out for this event 6/9/17
- *Information on the International Charter Space and Major Disasters activation by **Sistema Nacional de Emergencias** - Presidencia de la República/Uruguay for flooding in the Entre Rios Province 6/7/17*
  - NASA ARC Coordinator with HQ Team initiated Tier0 NASA Rapid Assessment following NASA draft Flood Playbook,
  - Team: includes Spanish speakers; ARC, GSFC, MSFC, JPL, LaRC, Dartmouth Flood Observatory, UMD, UAF, Remote Sensing Solutions, JRC, Global Flood Partnership…
  - Coordination: DOS/USAID Office of Disaster Assistance - Regional Office San José Costa Rica; Deputy Chief of Mission Uruguay Embassy DC

Uruguay Feedback and Collaboration

- Feedback with great appreciation for science and technology collaboration 6/10/17
- On behalf of **Information Systems' Area** of the National Emergency System (SINAE):

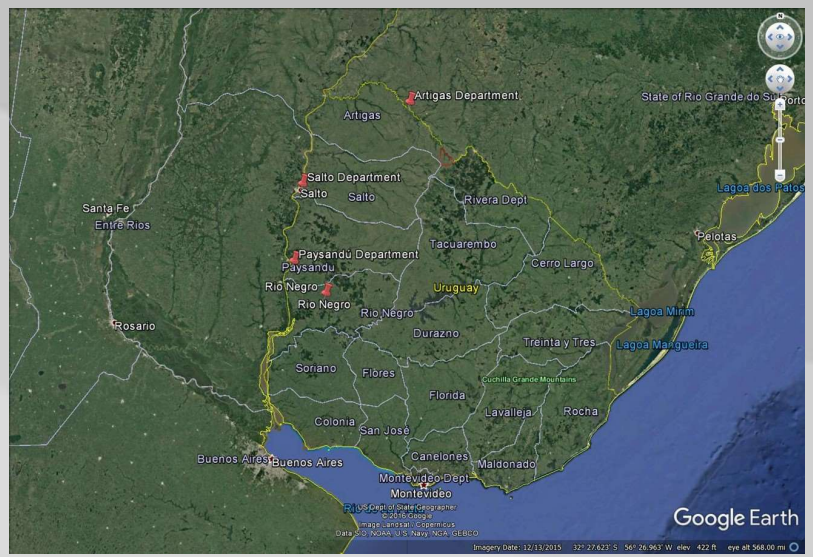
  - Disasters team working with SINAE specialists in GIS and mapping. Requested collaboration on all relevant information regarding the area covered by water, estimated flows of water in the Uruguay River, maximum peaks of height in points of the river, etc. comes in very well to analyze the event.

  - Informed that SINAE through the activation of the Disasters Charter have selected in the first instance the cities of Salto, Paysandú and a point of the Uruguay River in the Boundary of Brazil and Argentina in order to know the behavior at that point (given that the current event is caused by the great Water flows coming from the south of Brazil)

  - SINAE colleagues requesting if it is possible to receive optical and radar images on these areas. Besides all the predictions of models that NASA and PIs can make, such as the ones provide to date would be of great utility for us. We are coordinating on more specific ROIs for the wider Uruguay river area

Response

- Team coordination, maps (kml, jpgs, kmz…) and information sharing, site identification for areas of greater/lesser impact (6/8/17)



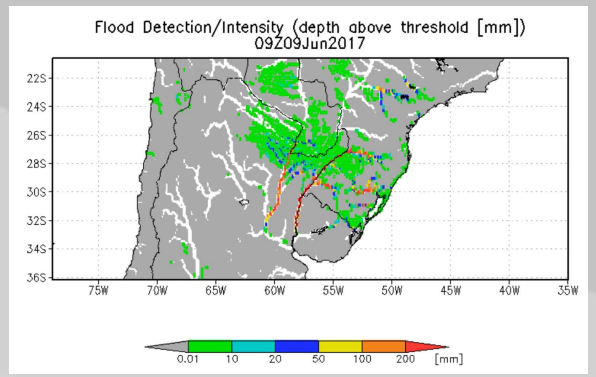
The 2 most impacted areas are the Departments of Salto and Paysandú with less impact at Río Negro and Artigas - sites (marked with a red pin) as well.

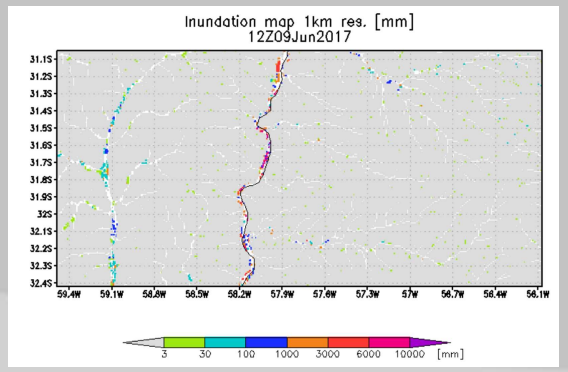
Inventory and assessment of available data sources

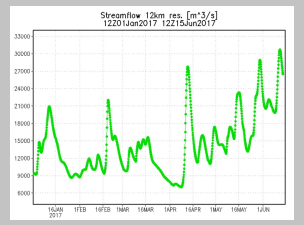
- Landsat 8 overpasses (Path: 225, Row 82) for Salto and Paysandú on May 1, May 17, and June 2 (with potential coverage of Rio Negro just southeast of Paysandú) and (Path 224, Row 81) for Artigas on May 10 and 26. The latter looks like a complete overcast day which aligns with the start of the rainfall event.

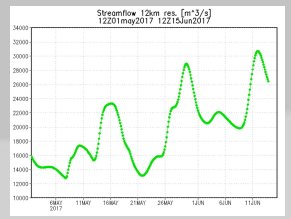
NASA Support Modeling

Global Flood Model (6/9/17) - usual complement of results routinely available on line--









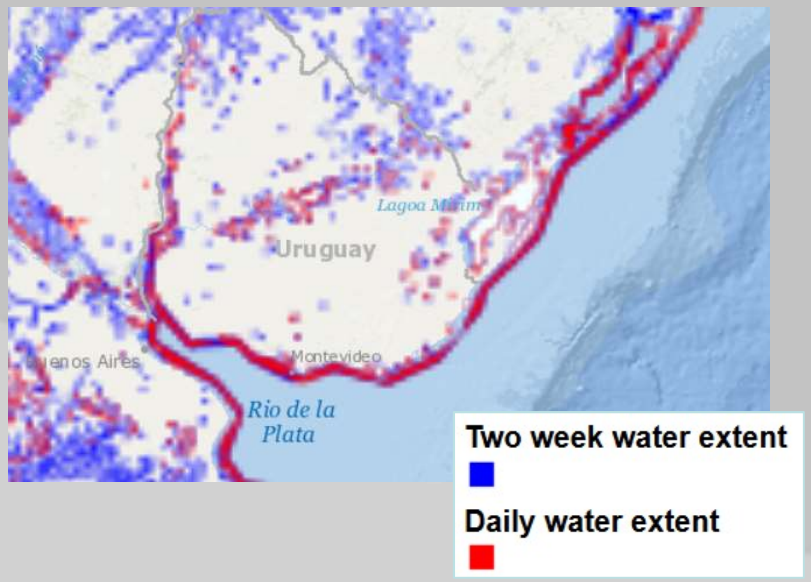
Overview with flooding along Uruguay R. along western boundary of Uruguay and in southern Brazil and NE Argentina.

1 km inundation estimates covering area seen in SAR map (from int'l charter), and stream flow history and forecast for next few days for Uruguay R. at 31.8S (about in middle of inundation map)

Results indicate flooding where expected with this latest episode being biggest peak of year and with forecast showing peak in a few days from now at this location.

Adler, UMD Global Flood Modeling System http://flood.umd.edu/

Flood Observatory



6/11/17 Current daily water extent layer - a 3-day moving water extent product and current 2-week water extent layer is a 14-day moving water extent product to specify the severity of long lasting floods. Large floods travel downstream leaving devastated areas behind. The 2-week product better maps the total extent of a flood.

http://floodobservatory.colorado.edu/WebMapServerDataLinks.html

http://floodobservatory.colorado.edu/geoserver/DFO_2wk_current_AF/wms?version=1.1.0

Brakenridge, DFO/CO

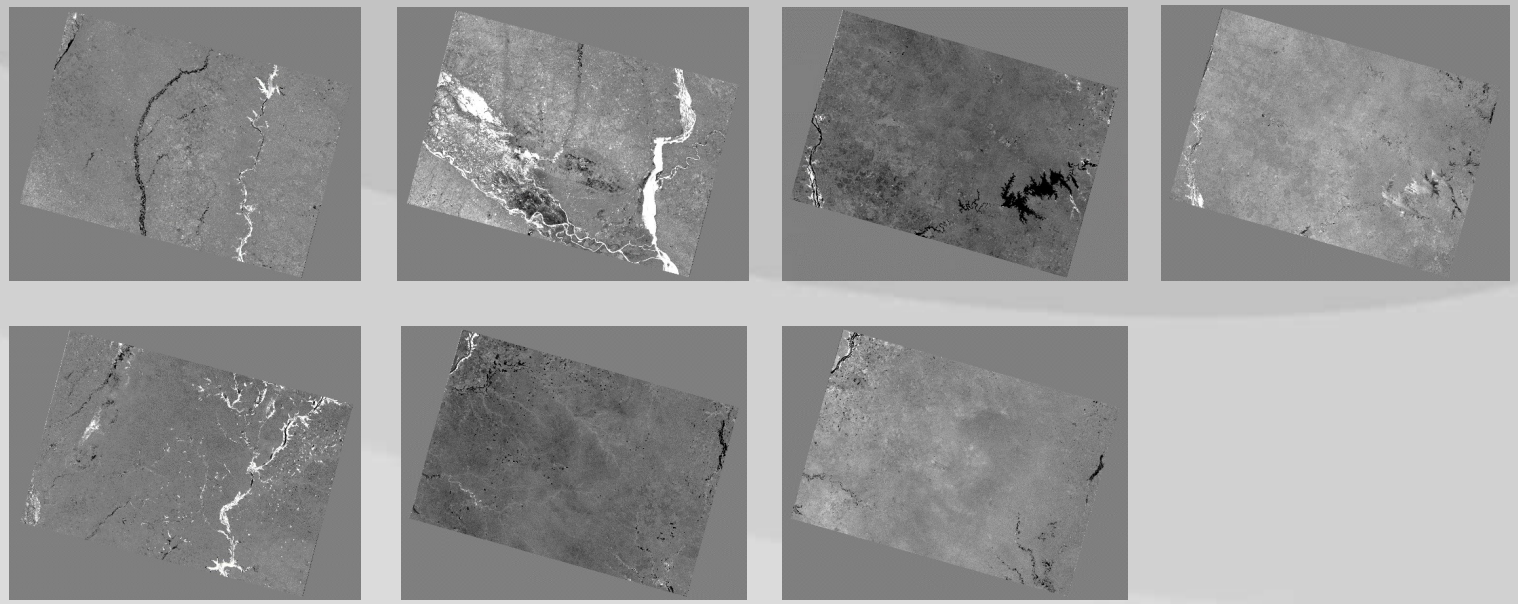
SAR Response

- SAR Tiger Team: AFS, MSFC, DFO, JPL, GSFC
  - AFS stood up SAR-VIEWS HyP3 *Uruguay Flood - Change Detection (SACD)* subscription for this event 6/9/17 . This a Beta-site and not yet for broad use and distribution – the NASA and partner team are using to share data on this event. Additional will be shared only with appropriate conditions explained.

http://hype3.asf.Alaska.edu/
Meyer, Alaska Satellite Facility, Cloud-based Hyp3 Data Processing Engine and log in using your Earthdata credentials.

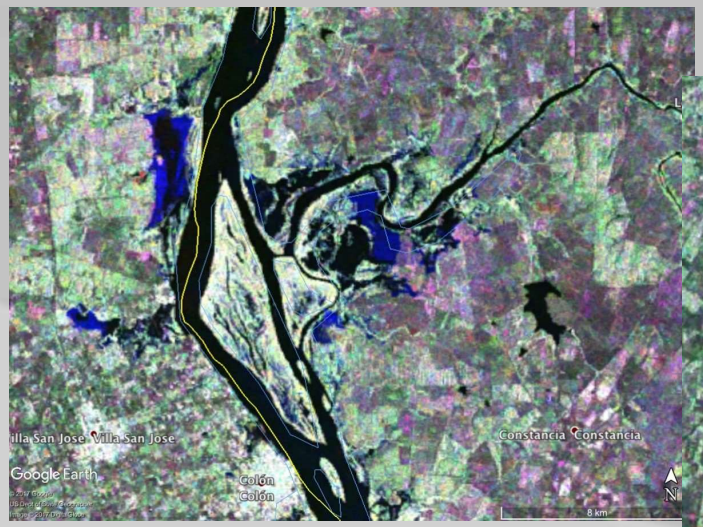
Updates on SAR-VIEW site as of 6/11/2017

Collected imagery pending further analysis and interpretation

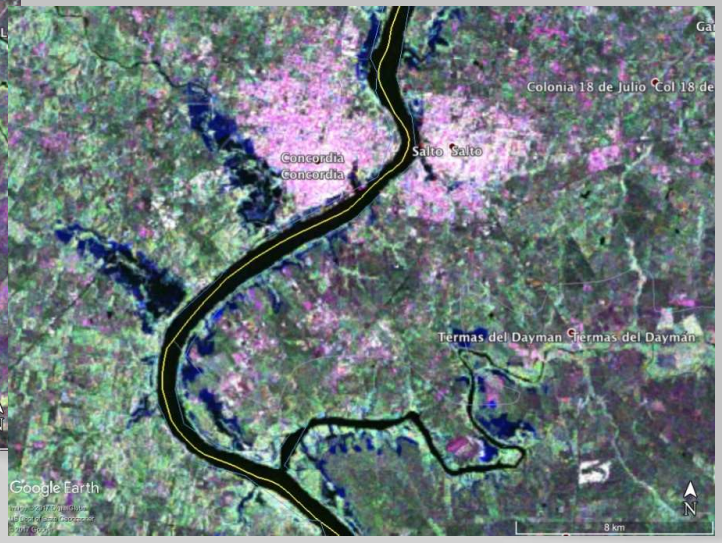


Preliminary - Amplitude Change Detection

Colon



Salto



Osmanoglu, GSFC

Two examples of recent flooding from Uruguay using SAR imagery. The RGB uses two Sentinel 1 images, one from 21 May 2017 and the other 2 June 2017.

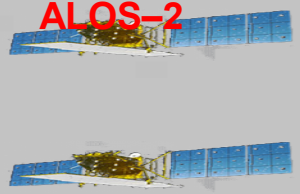
Color Interpretation:
Black: Existing water on both acquisitions.
Blue: New water on 20170602
Red/Green: Land."

By compositing them in a certain way, the flooded areas are able to appear in rich blue color in the RGB. This makes the product easy to explain to and interpret by end-users and decision makers. This product was constructed by Osmanoglu of GSFC.

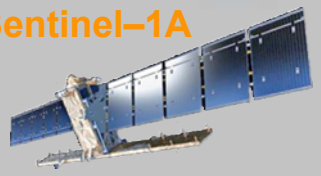
Flood Response

NASA Coordinates Synchronized Space-Air-Ground Observations for Louisiana Floods

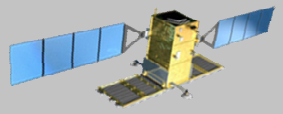
ALOS–2



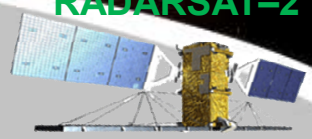
Sentinel–1A

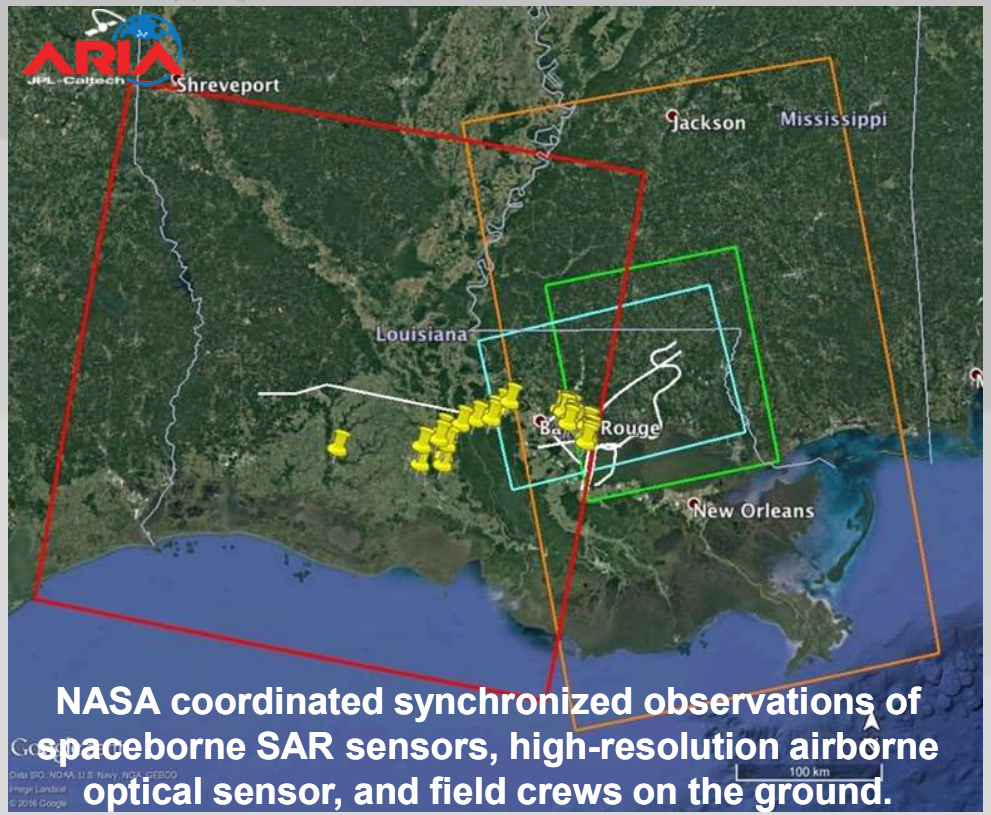


COSMO-SkyMed



RADARSAT–2



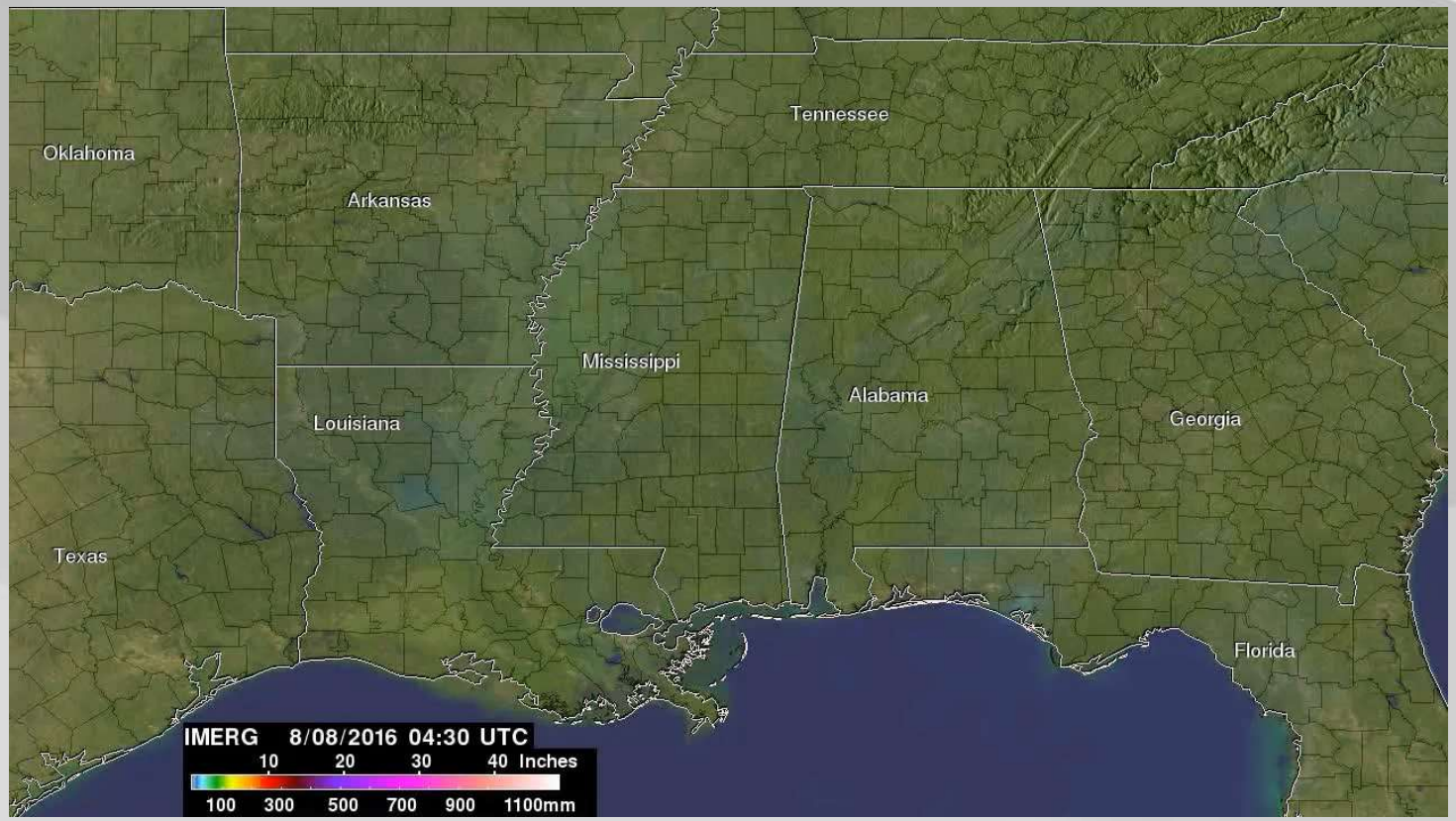


NASA coordinated synchronized observations of spaceborne SAR sensors, high-resolution airborne optical sensor, and field crews on the ground.

NOAA

FEMA

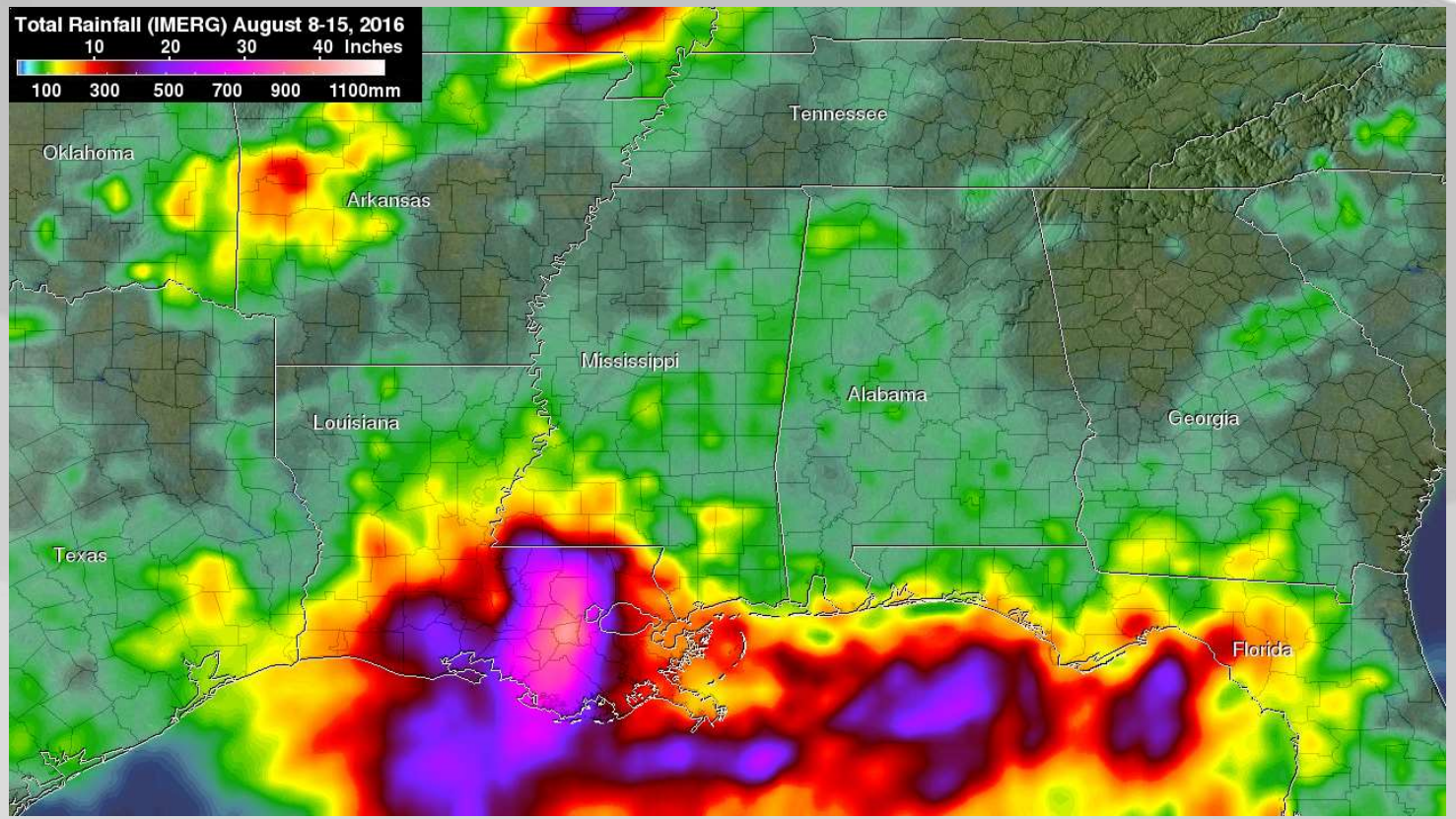
NASA Observes Historic Rainfall in Louisiana



NASA's IMERG data from Aug. 8 to Aug. 15, 2016 showed over 20 inches (508 mm) of rainfall was estimated in large areas of southeastern Louisiana and extreme southern Mississippi. Even greater rainfall totals of 30 inches (762 mm) were indicated in a small area of Louisiana west of Lake Pontchartrain.

Credits: NASA/JAXA, Hal Pierce

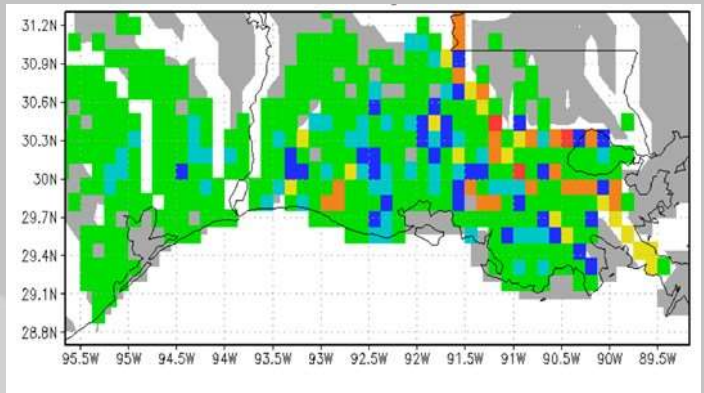
NASA Global Precipitation Mission – GPM IMERG



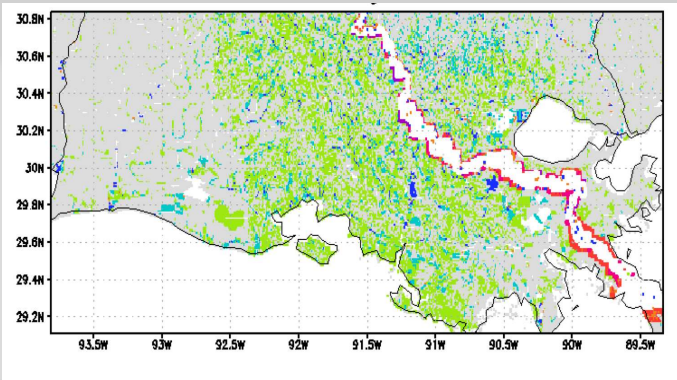
NASA's IMERG data from Aug. 8 to Aug. 15, 2016 showed over 20 inches (508 mm) of rainfall was estimated in large areas of southeastern Louisiana and extreme southern Mississippi. Even greater rainfall totals of 30 inches (762 mm) were indicated in a small area of Louisiana west of Lake Pontchartrain.

Credits: NASA/JAXA, Hal Pierce

Global Flood Mapping System – GFMS

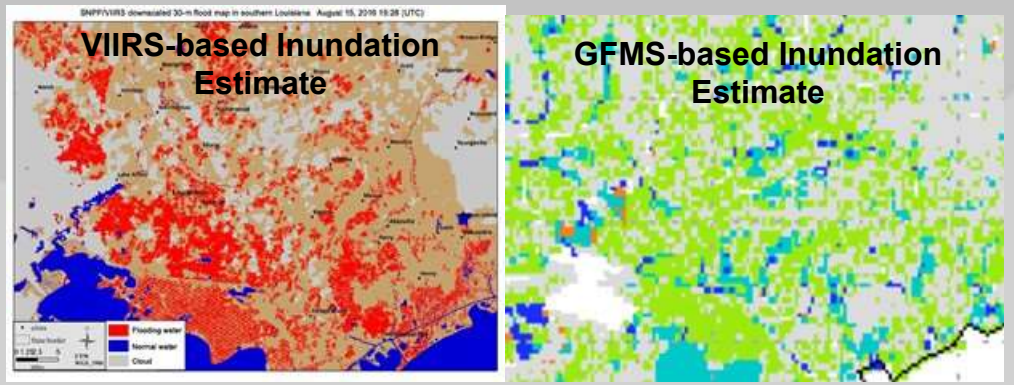


Global Flood Monitoring System (GFMS)
Adler/Wu University of Maryland



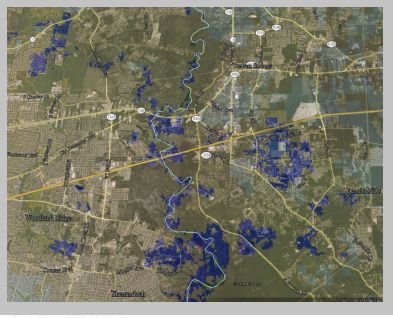
Credit: Bob Adler and Huan WU, UMD

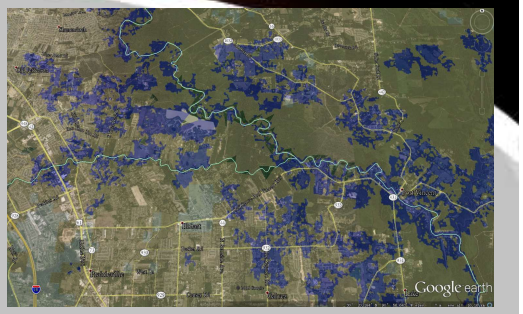
Satellite precipitation estimates merged via the GPM product are utilized as a key Input into the Global Flood Monitoring System (GFMS) utilizing land surface and routing models at 12 and 1 km resolution to estimate the occurrence and intensity of floods. The hydrological calculations are extended into the future (out to five days) using GEOS-5 rainfall predictions.

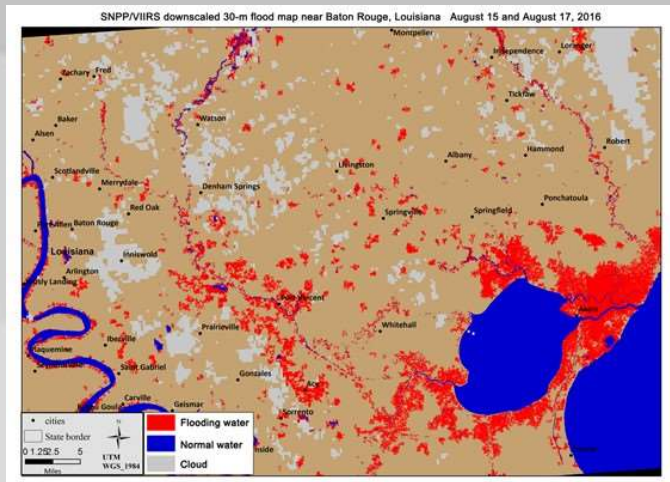


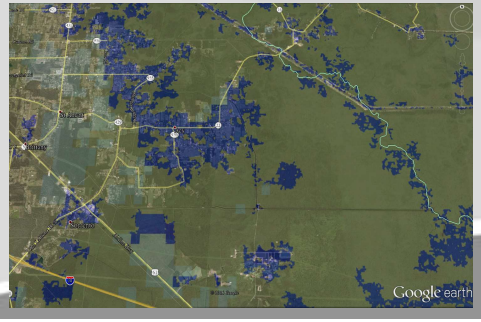
GFMS showing current conditions and forecasts (3-hr resolution) provided to help plan their response to estimate number of structures and homes impacted.

NPP Suomi VIIRS Flood Maps



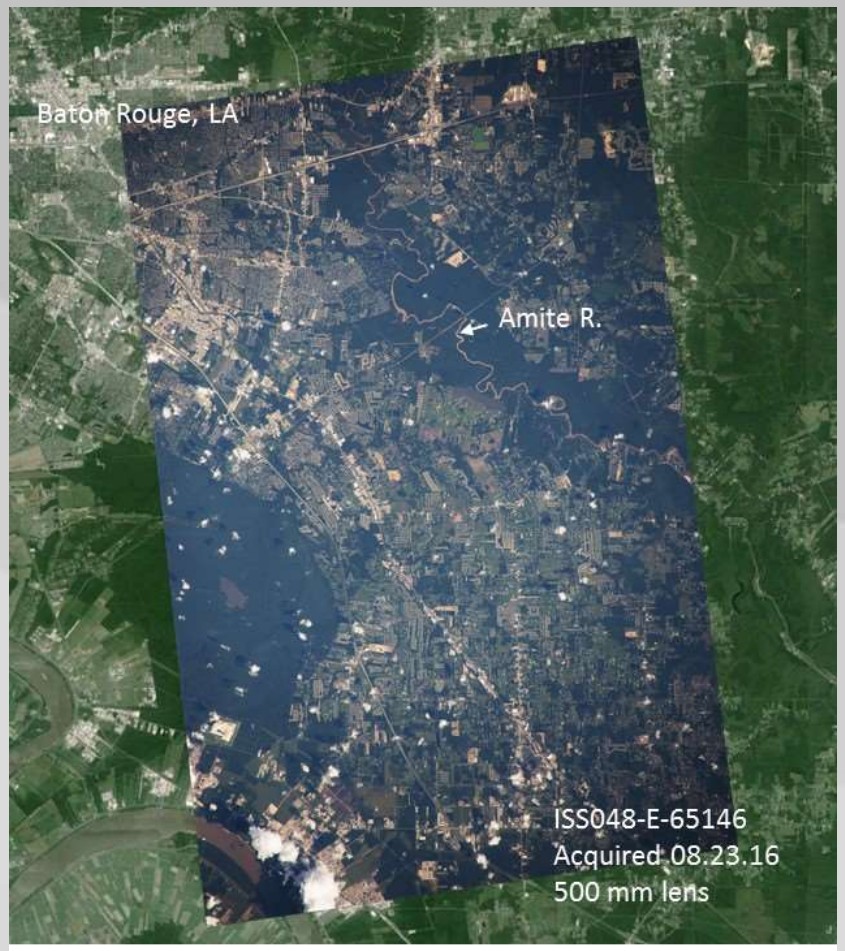






August 15-17, 2016 VIRRS Flood maps courtesy of Sanmei Li, GMU.

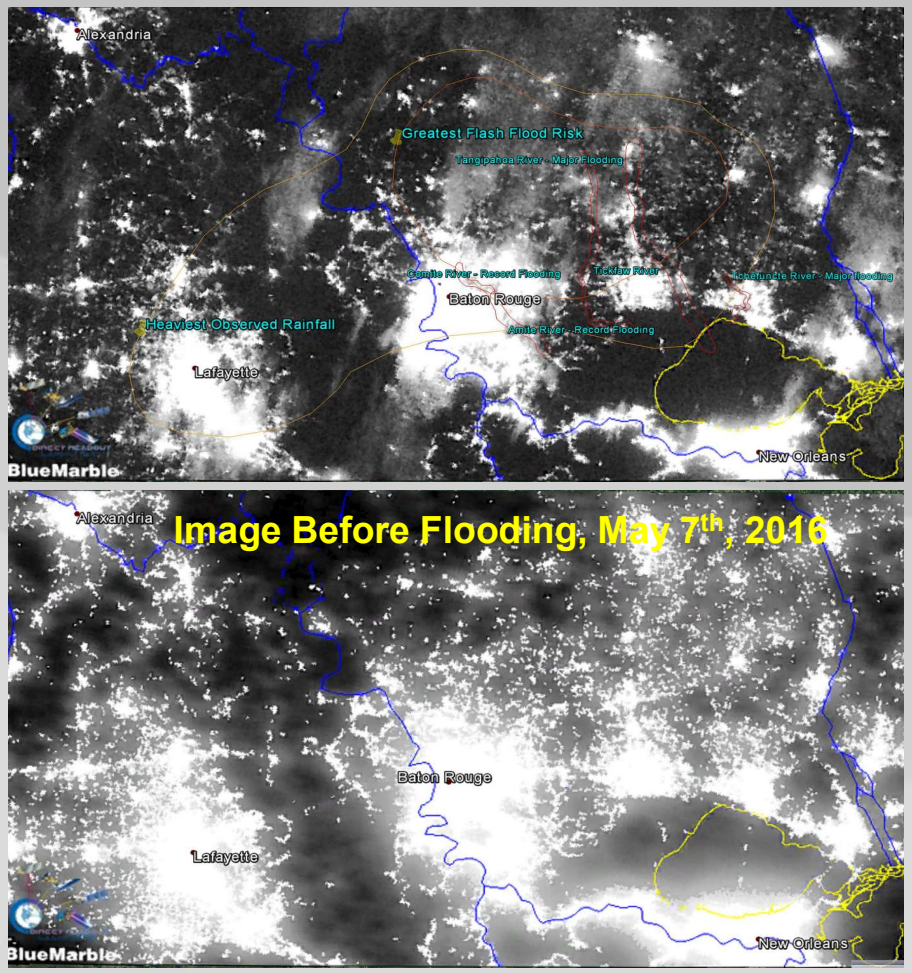
International Space Stations (ISS) Handheld Digital Camera Photography



- ISS USOS crew acquired imagery of flooding area on Aug 16, 17, 23 in response to target requests from JSC Crew Earth Observations ops team
- Downlinked imagery reviewed and manually georeferenced prior to delivery to USGS HDDS team
- Data potentially useful for validation of SAR and flood extent model products

Suomi NPP VIIRS Day-Night Band Detects Power Outages

VIIRS DNB Image During Flood Event, August 15th, 2016



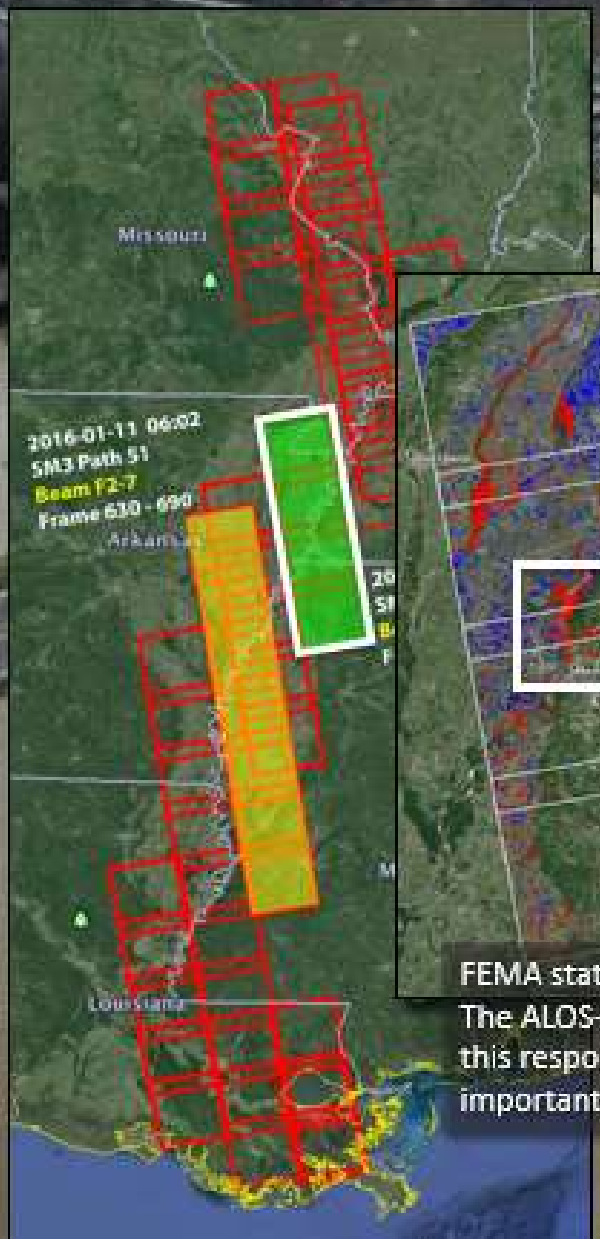
Credit: Dalia Kirschbaum and Miguel Roman, NASA GSFC

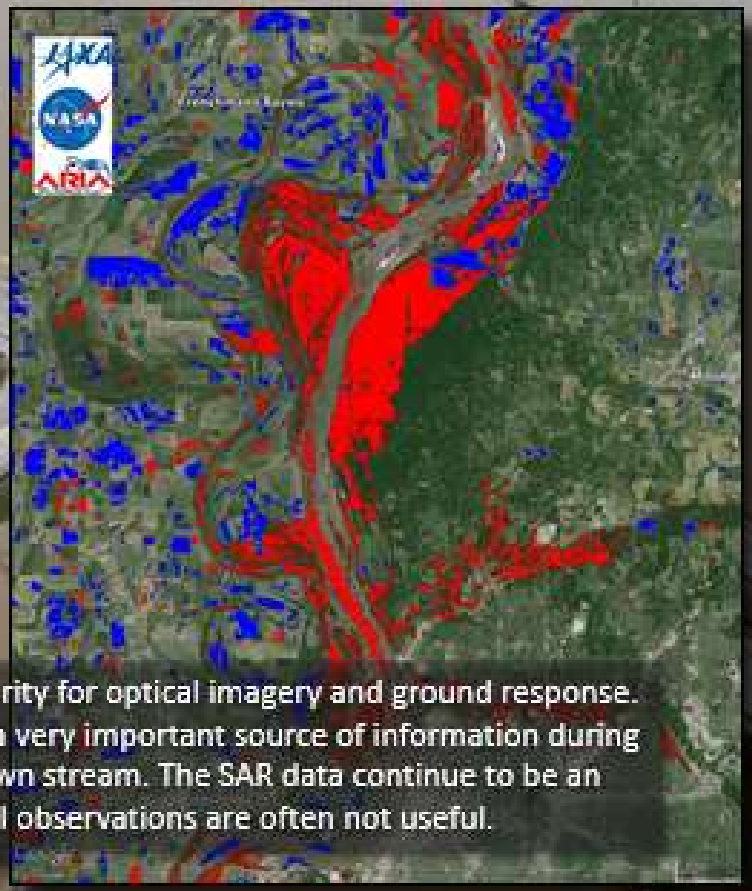
NASA Night time optical data for assessing impact of the Louisiana floods at the request of FEMA.

Data was used for determining power outages as a means of mapping impact zones. (NASA Direct Readout Lab) and by DHS/FEMA in helping to restore power after Hurricane Sandy.

2016 Midwest Floods

Sensor: ALOS-2 SAR (JAXA)
Coverage: 70km x (240km + 420km)
Resolution: ~12m
Blue pixels: Open Land Floods
Red pixels: Vegetation Floods
Available online at
http://aria-share.jpl.nasa.gov/events/

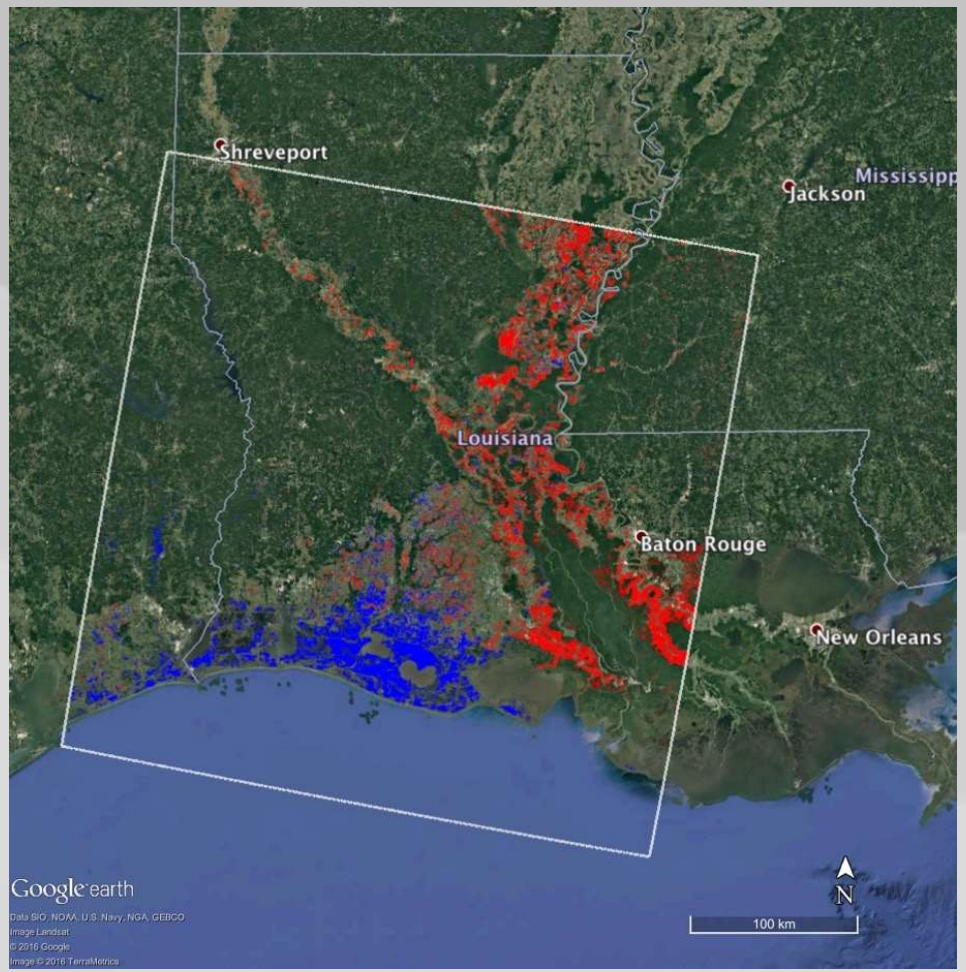


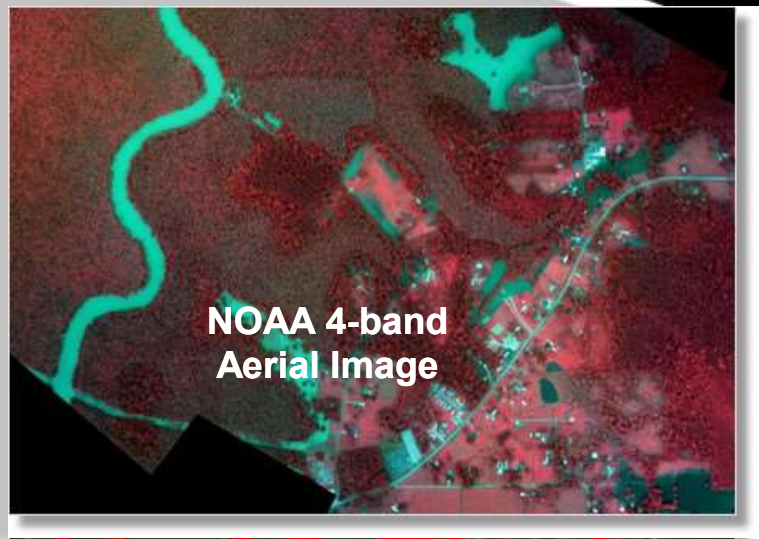


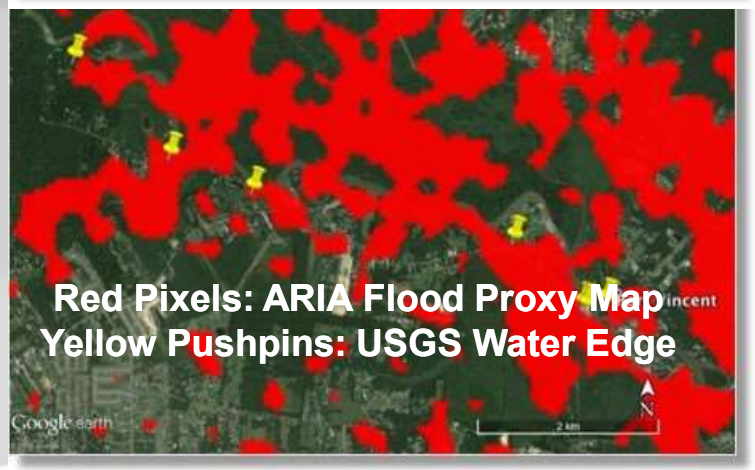
FEMA stated that SAR provides inspection priority for optical imagery and ground response. The ALOS-2 data and the products have been a very important source of information during this response as the flood crest has moved down stream. The SAR data continue to be an important resources during times when optical observations are often not useful.

Jeff Roberson/AP Photo

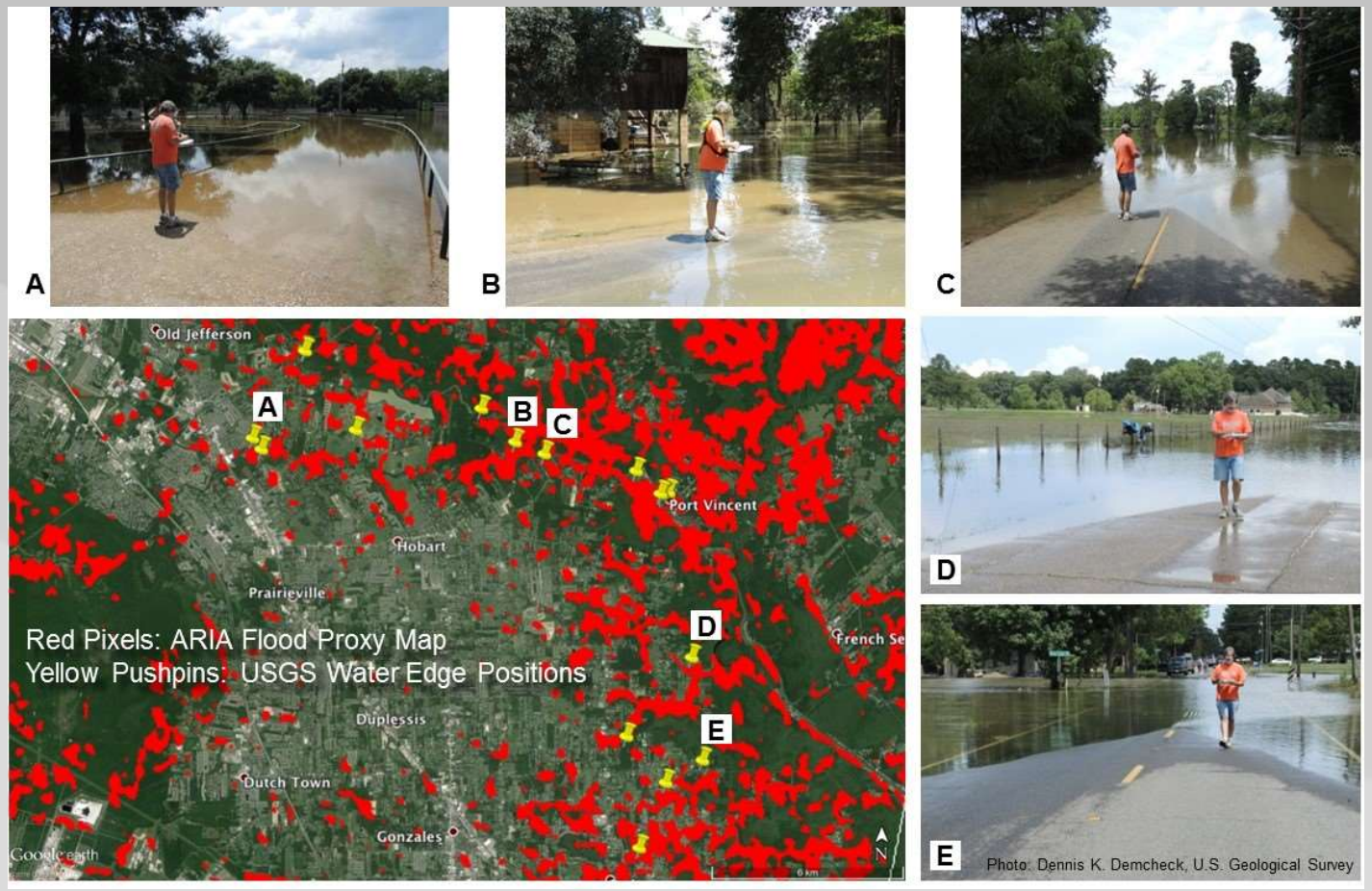
Flood Proxy Map Derived from ALOS-2 SAR Data and Calibrated with Independent Observations







Flood Proxy Map Derived from ALOS-2 SAR Data and USGS Ground Observations (Water Edge Survey)



GPM Observes Pineapple Express rainfall, causing flooding in California January 2017

An atmospheric river ("Pineapple Express") delivered over 5 inches of rainfall in parts of California in early January, 2017 (bottom) as viewed by GPM's IMERG data. The 30-day rainfall anomalies ending Jan. 10th show TRMM Multi-satellite Precipitation Analysis from 2017 (top right) and 2016 (bottom, right).

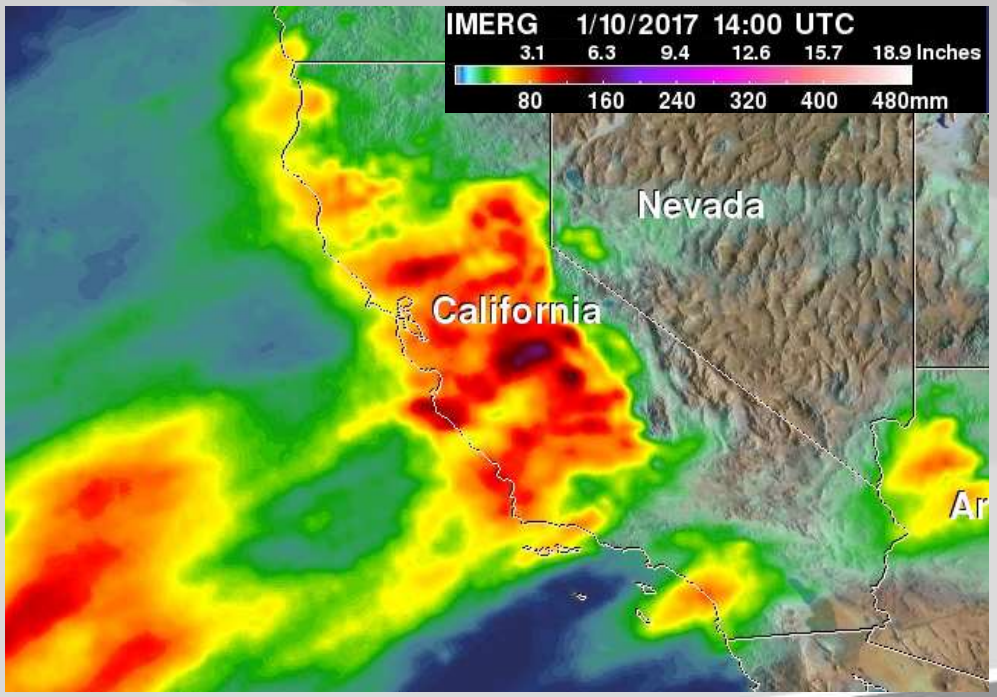
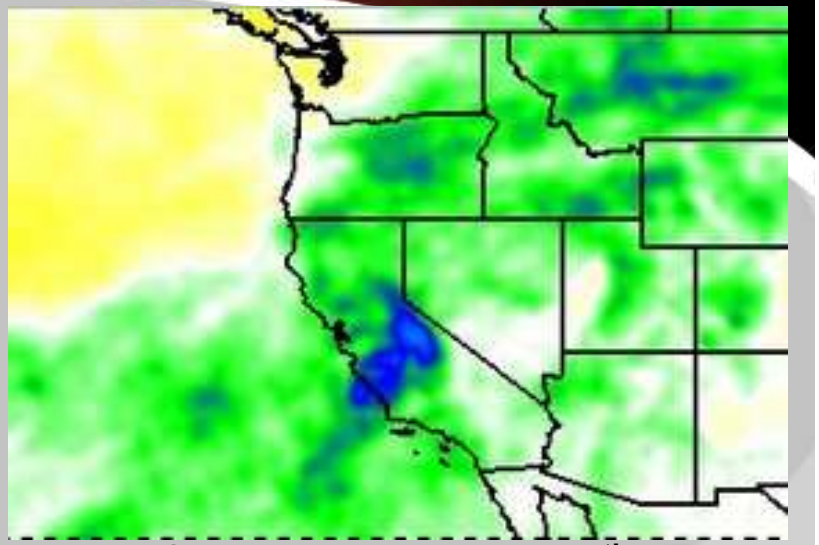
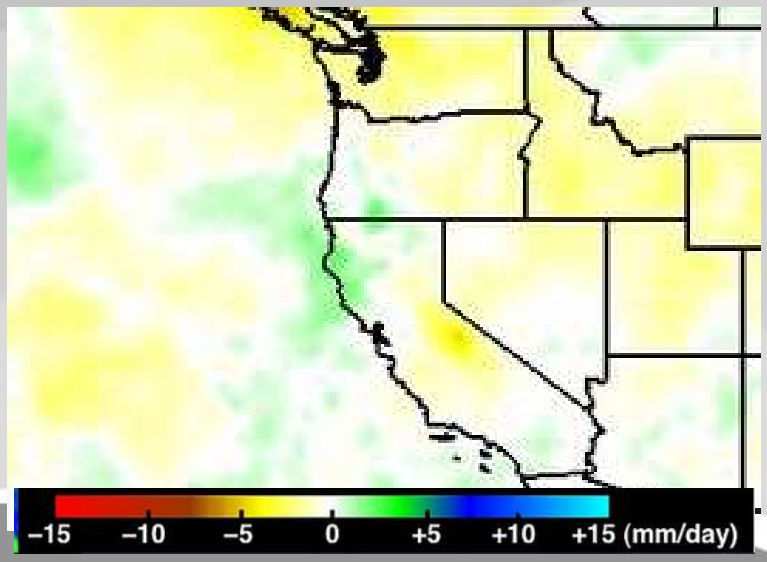


Image credit: Hal Pierce, SSAI/GSFC

Rainfall anomalies, Jan 10th, 2017

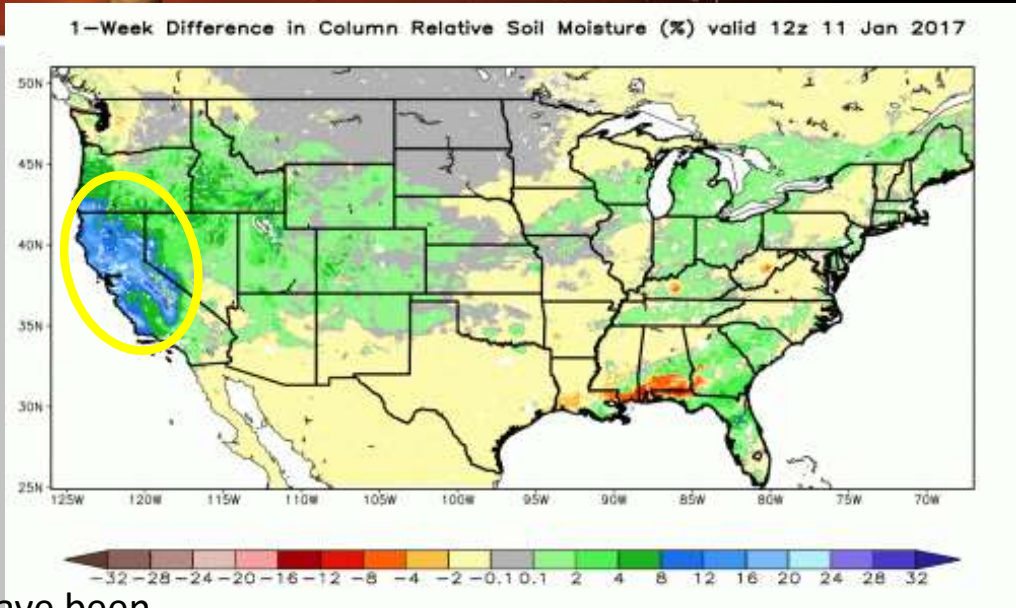


Rainfall anomalies, Jan 10th, 2016

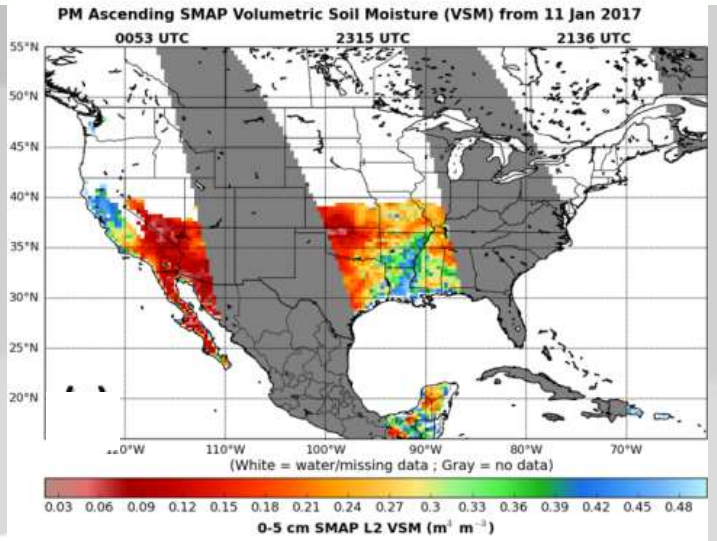


SPoRT Soil Moisture Products Highlight California Flood Potential January 2017

- MSFC/SPoRT runs a real-time version of the NASA Land Information System (LIS) to output soil moisture products used in identifying areal flood potential during CA floods in January
- Surface soil moisture one-week change product from LIS (upper right) shows >35% change in some areas meaning higher runoff/flood potential, consistent with other high-profile flood events



- Select NOAA/National Weather Service offices have been using these products for identifying flood potential since early 2014
- Level 2 SMAP soil moisture products (lower right) from the same day show very high soil moisture values in CA
- SPoRT has completed assimilation of the L2 SMAP soil moisture into the real-time LIS and is currently validating this offline run
- Working with to bring SMAP data 1) into the National Water Model and 2) to evaluate impacts on regional numerical weather prediction forecasts

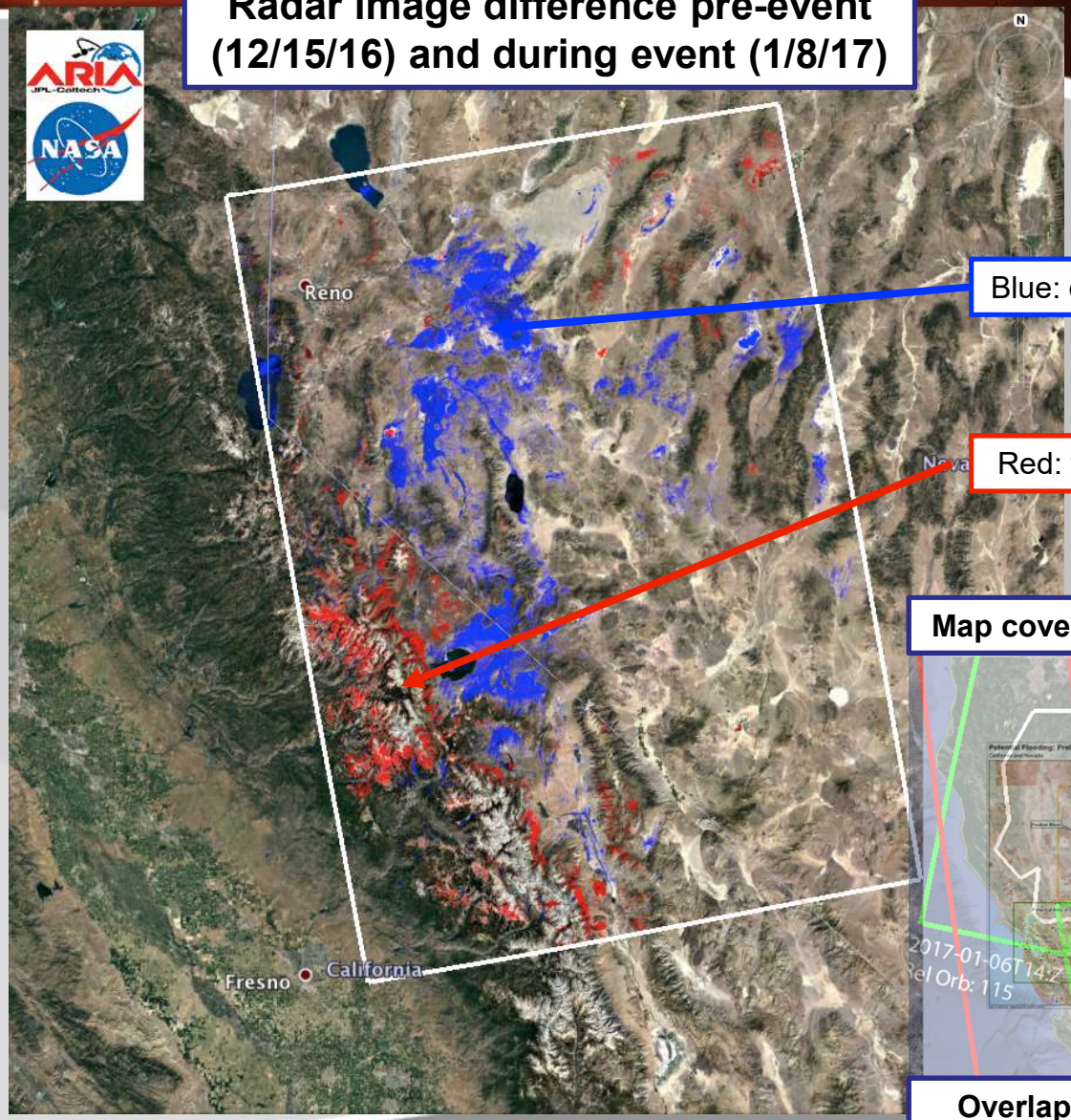


Bradley Zavodsky (NASA/MSFC), Jonathan Case (ENSCO, Inc.), Clay Blankenship (USRA)

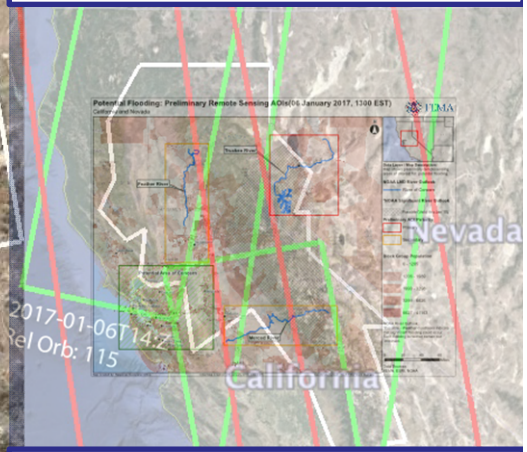
Synthetic Aperture Radar Uncovers Flooding in NV

Flood Proxy Map (FPM) covering an area of 155-by-224 miles (250-by-360 km), derived from Sentinel-1's pre- (2016-12-15 6 PM PST) and during-the-event (2017-01-08 6 PM PST) Synthetic Aperture Radar (SAR) amplitude images. The colored pixels represent areas of potential flood (Red: flooded vegetation, Blue: open water flood). Different irrigation conditions on the two data acquisition dates can produce errors on agricultural lands. This FPM should be used as guidance to identify potential areas of flooding, and may be less reliable over urban areas or snow cover.

Radar image difference pre-event (12/15/16) and during event (1/8/17)



Map covers FEMA Primary AOI



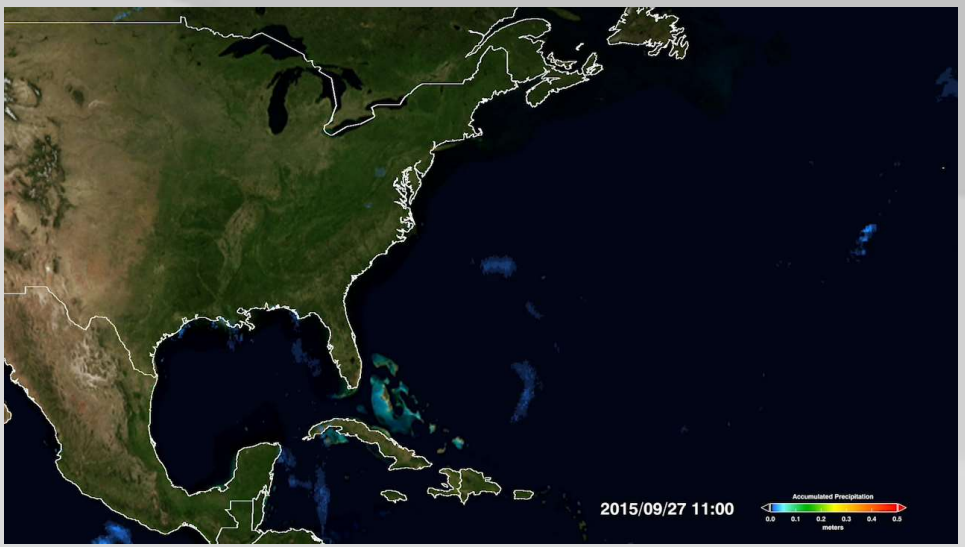
Overlap of Sentinel ground tracks and FEMA AOIs

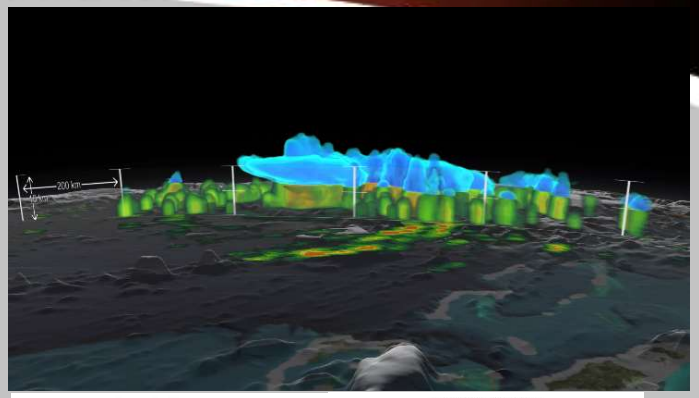
Science POC: Sang-Ho Yun Coordinator POC: Rashied Amin Date: 1/17/17

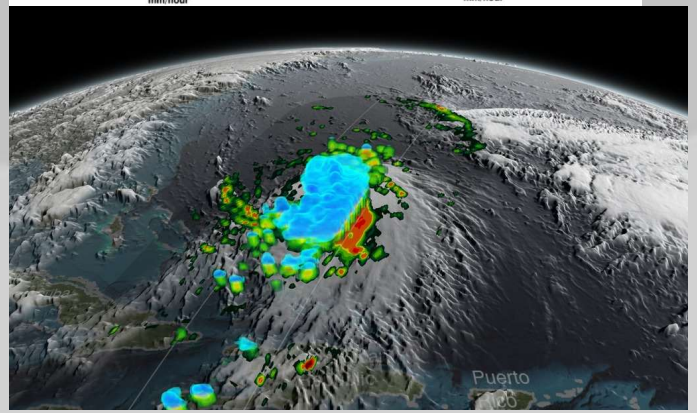
Hurricane Response

Global Precipitation Measurement (GPM) Sees inside Hurricane Joaquin

Joaquin became a tropical storm on the evening (EDT) of Monday, September 28th midway between the Bahamas and Bermuda. GPM captured Joaquin Tuesday, September 29th, 2015 at 21:39 UTC



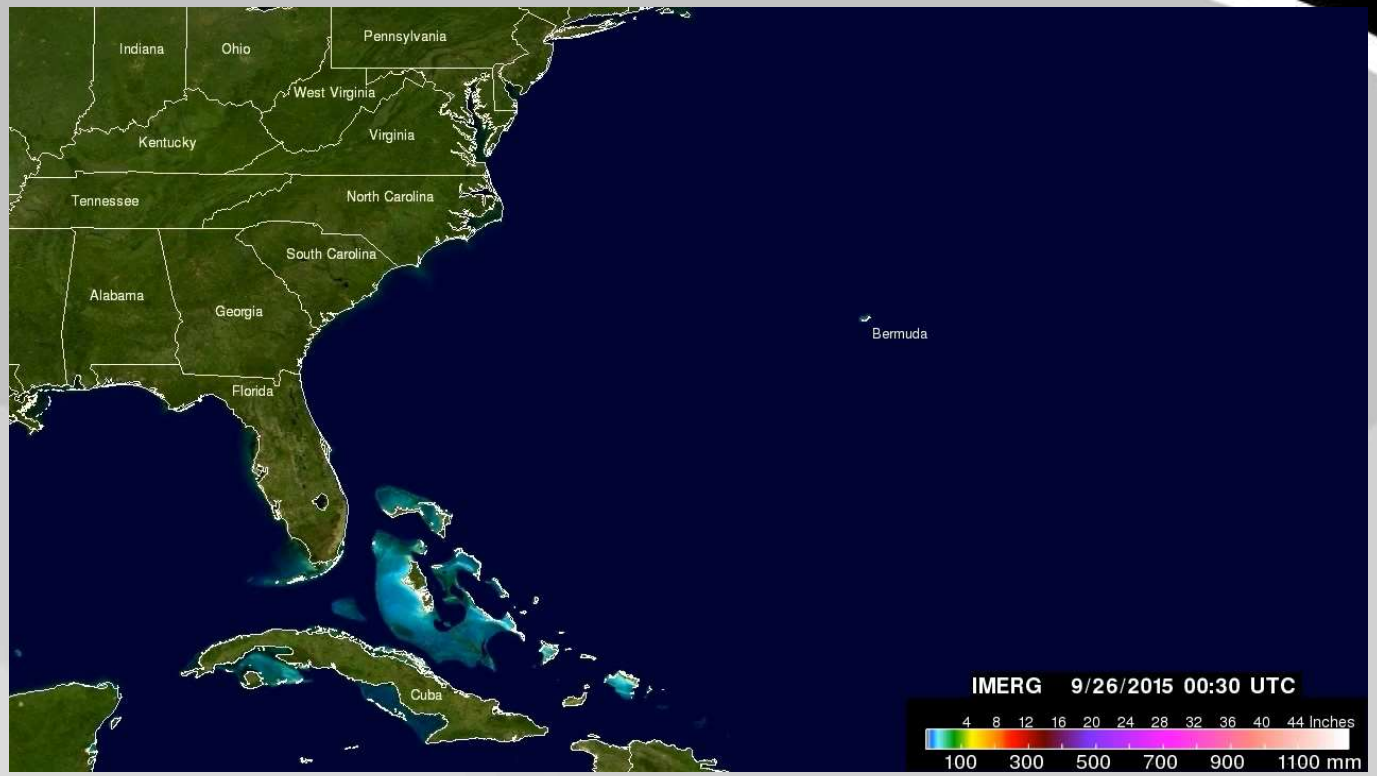




Visualization available at:
https://svs.gsfc.nasa.gov/vis/a000000/a004300/a004367/joaquin_w360_1080p30.mp4

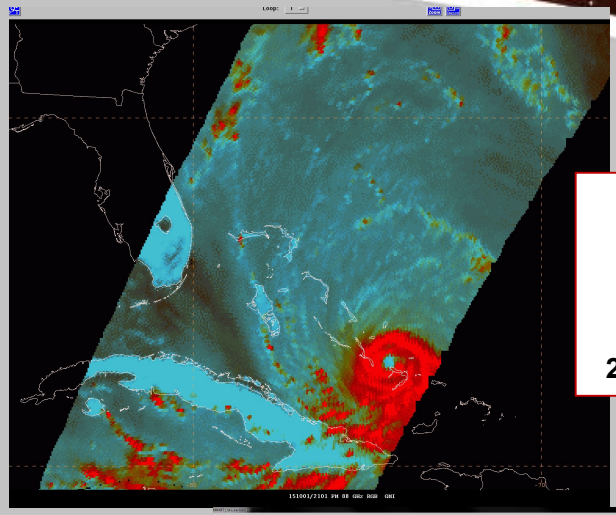
GPM Observes Historic Rainfall Totals for Nor'easter and Hurricane Joaquin

NASA's Integrated Multi-satellitE Retrievals for GPM (IMERG) data were used to estimate the historic amount of rain that fell during the past week in the Carolinas.

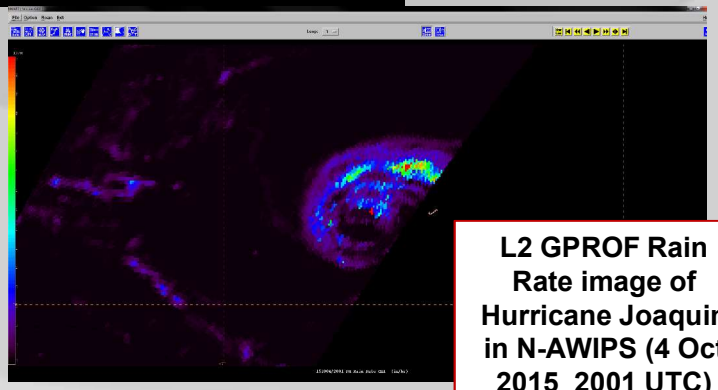


GPM data used in Operational Decision Support at the National Hurricane Center

NASA's Short-term Prediction Research and Transition (SPoRT) Center has been working with the National Weather Service to transition GPM observations into their decision support systems.



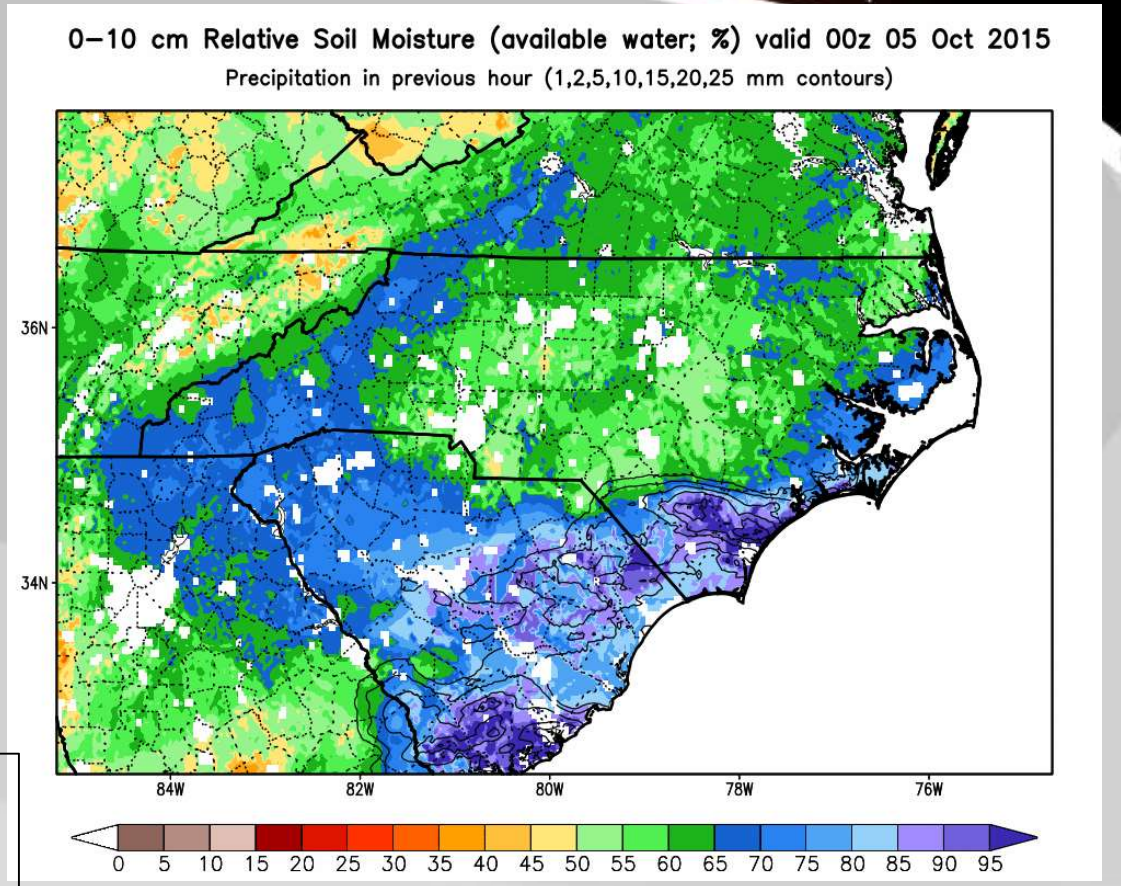
89 GHz RGB image of Hurricane Joaquin in N-AWIPS (1 Oct 2015 2101 UTC)



L2 GPROF Rain Rate image of Hurricane Joaquin in N-AWIPS (4 Oct 2015 2001 UTC)

Soil Moisture modeled from NASA's Land Information System

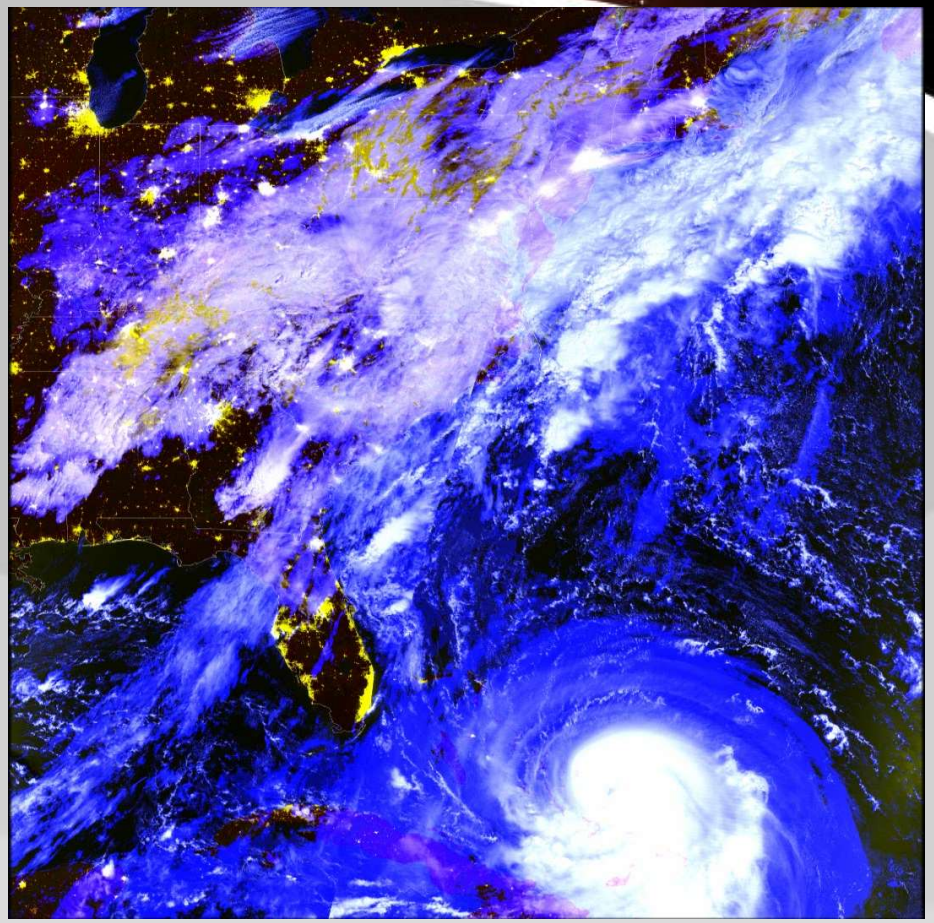
NASA's Land Information System runs operationally at MSFC using NOAA Stage IV precipitation and other forcing inputs to produce analyses and short term forecasts of soil moisture and other parameters. GPM and SMAP data are being integrated into this system. .



In the graphic (right), dark blues and purples suggest that these soils are holding 70-95+% of their water capacity, hence significant and immediate runoff that contributes to flash flooding.

Applications of Suomi-NPP VIIRS Day/Night Band for Disaster Response

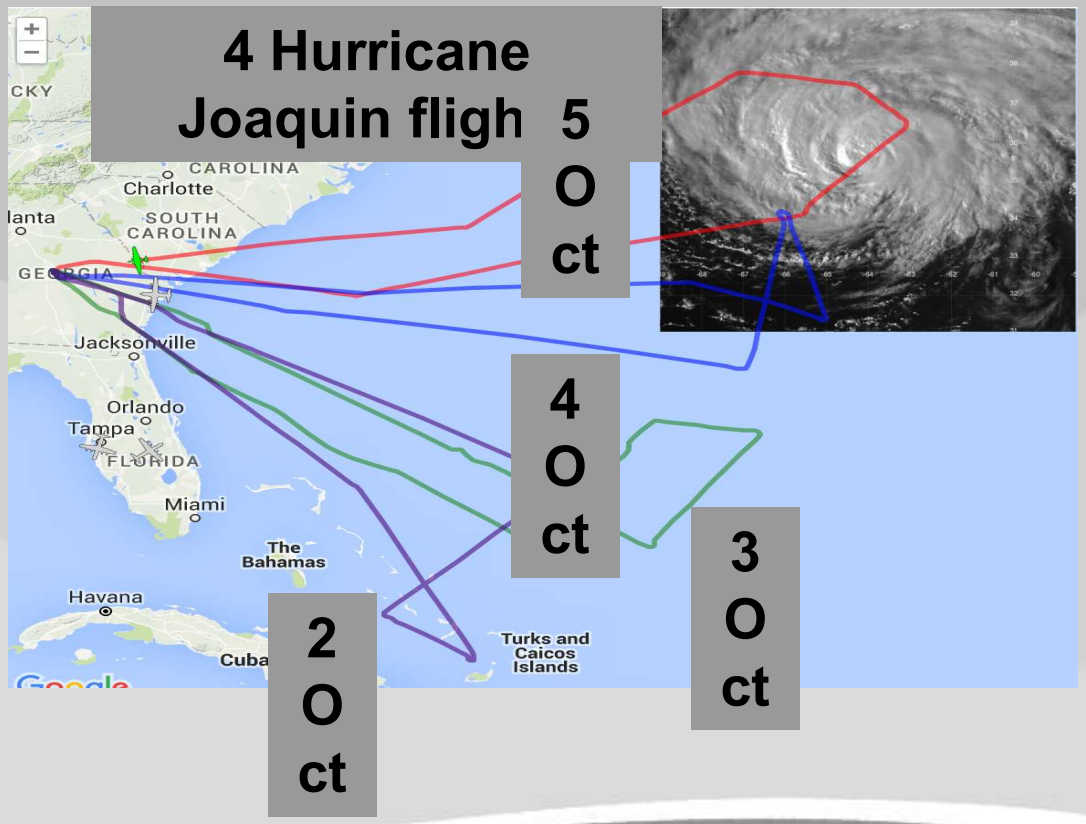
Images on right shows VIIRS Day/Night Band highlighting Hurricane Joaquin and the East Coast Nor'easter during October 1-5th, 2015 when Hurricane Joaquin was a Category 1 storm.



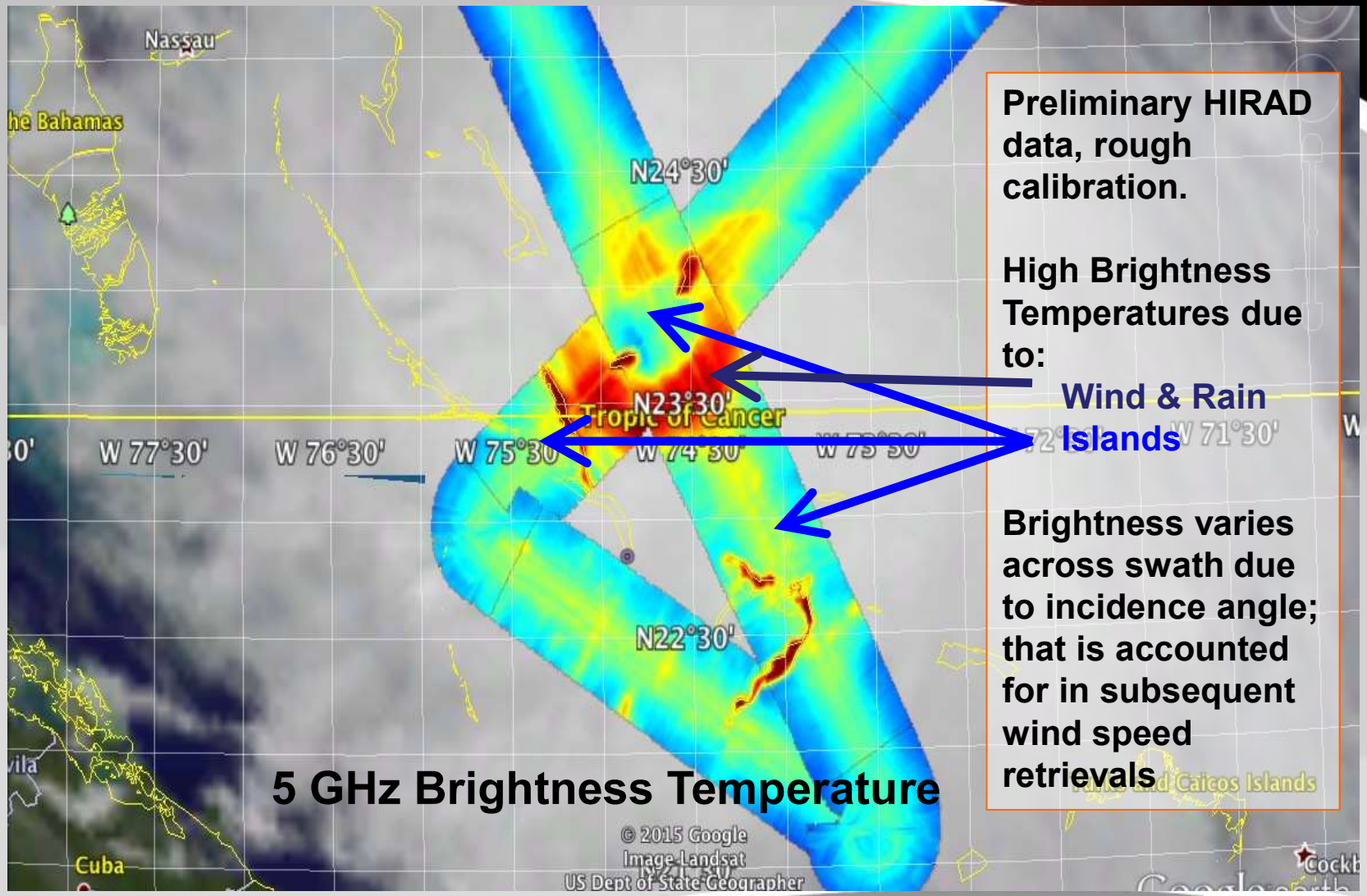
Hurricane Joaquin Over Flights
Tropical Cyclone Intensity Experiment (TCI 2015)
supported *by Office of Naval Research*

NASA WB-57 (JSC) carrying:

- **High Definition Sounding System (HDSS) dropsondes by Yankee Environmental Systems Measure vertical profiles of Temperature, Pressure, Relative Humidity, Wind**
- **Hurricane Imaging Radiometer HIRAD (MSFC) measures ocean surface wind speed**



Hurricane Joaquin
Friday 02 October 2015 Pass 2: 18:35 Z



Preliminary HIRAD data, rough calibration.

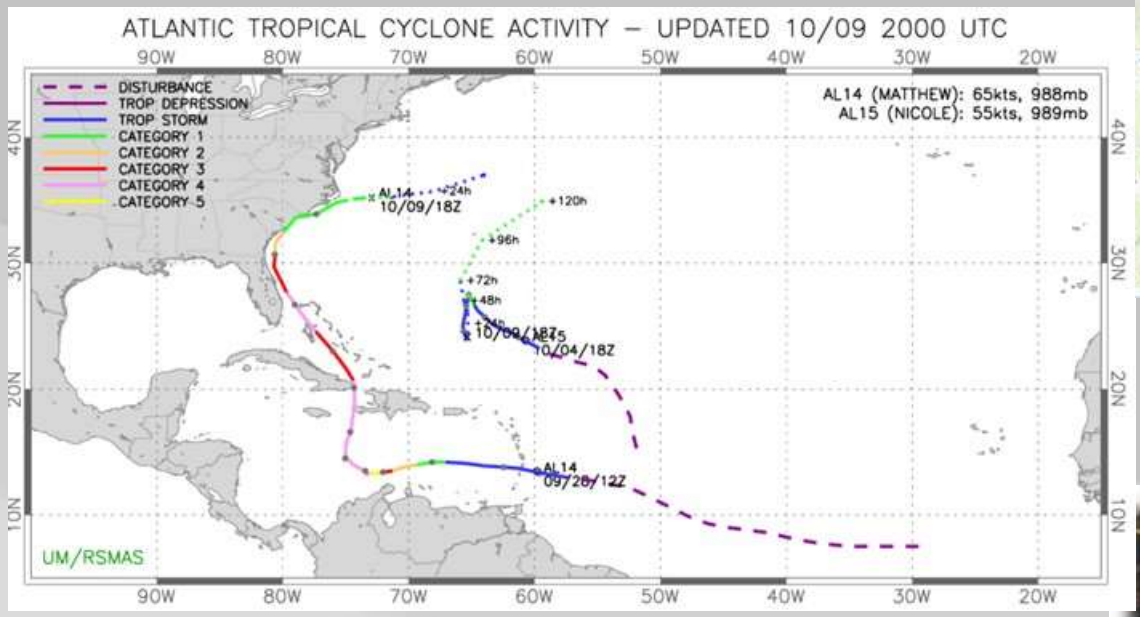
High Brightness Temperatures due to:

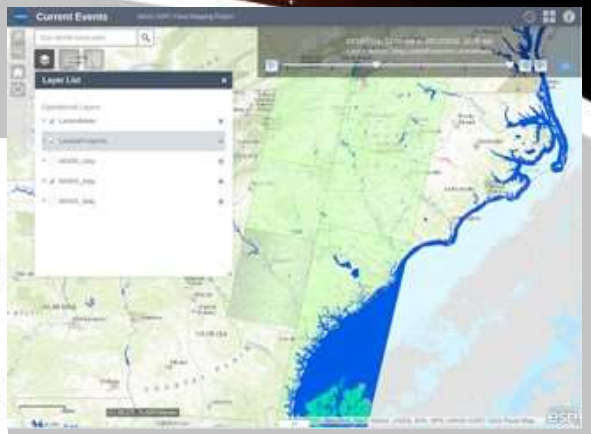
Wind & Rain

Islands

Brightness varies across swath due to incidence angle; that is accounted for in subsequent wind speed retrievals

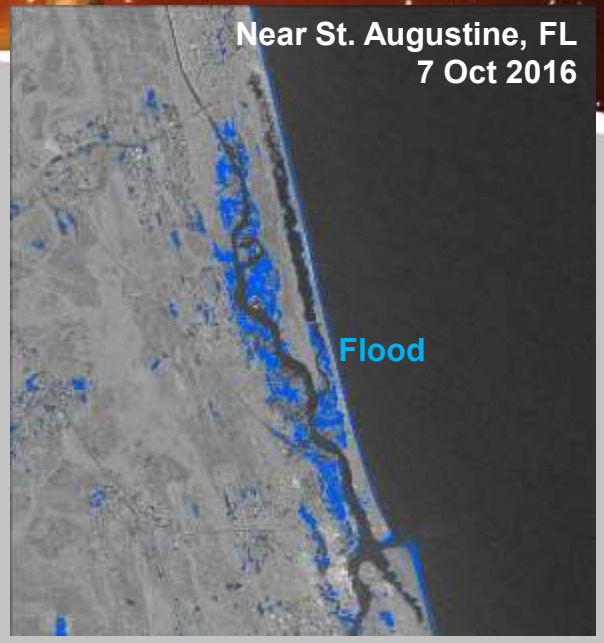
Hurricane Matthew October 2016



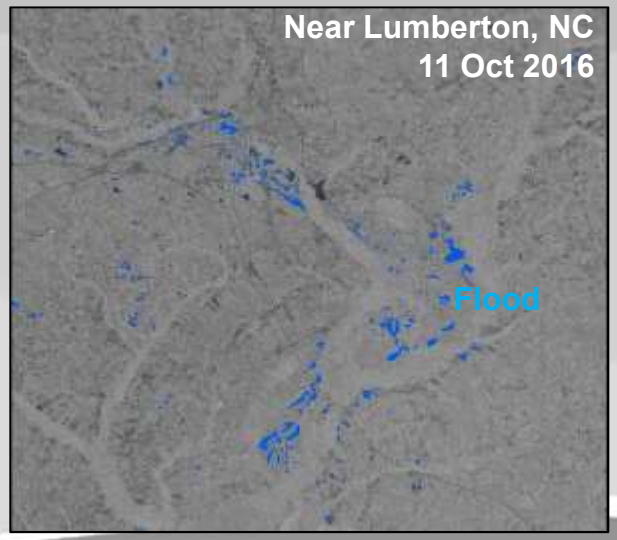


Flood Mapping SAR Applications

- In preparation for NISAR's launch, Disasters Team collaborators are working with a variety of platforms to develop products in support of disaster response efforts.
- Through the International Charter activation assets, the team obtained data through the CEOS Flood Pilot, and through Sentinel 1A/1B acquisitions from ESA. Team members contributed flood maps to USGS/HDDS and FEMA partners, including:
  - SAR Imaging of Haiti, the Dominican Republic and eastern Cuba
  - Products for the U.S. coastline including the eastern coast of Florida (via Charter/Radarsat-2) and the Carolinas (via Sentinel)
- Collaborations among team members are ongoing to share and explore best practices, improve products, their validation, and automation to provide service to FEMA and international partner disaster response efforts, and to build a user community in preparation for the launch of NISAR.



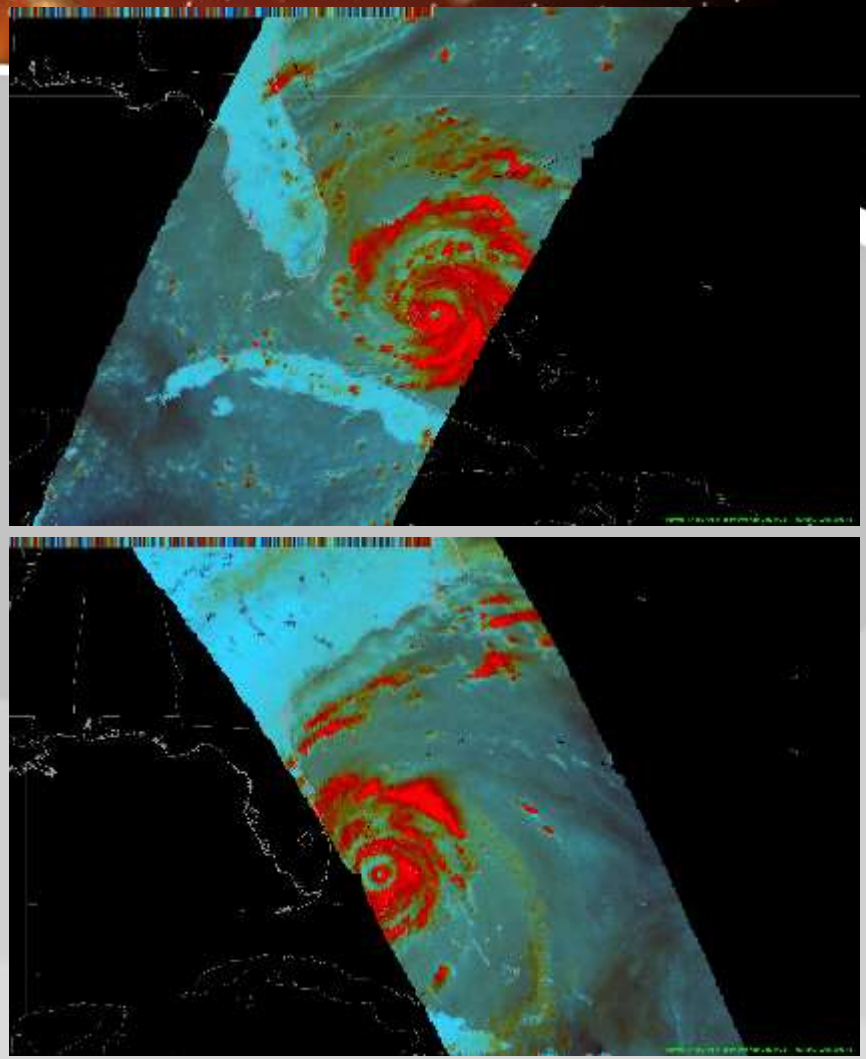
Imagery was acquired by RADARSAT-2 on 7 October 2016 RADARSAT-2



Sentinel 1A/1B imagery collected in partnership with ESA and delivered through the Alaska Satellite Facility / UAF.

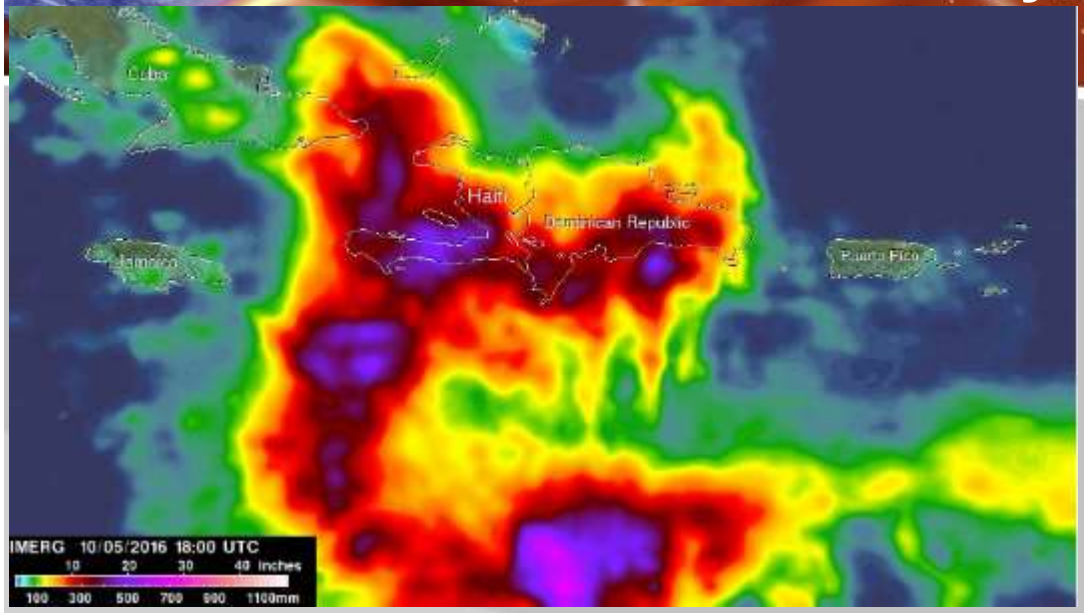
Imaging Matthew's Circulation with GPM

- Collaborative effort between the GPM science team and NASA SPoRT provided brightness temperature and IMERG products to NOAA's National Weather Service and the National Hurricane Center.
- Images on the right capture snapshots of Matthew using NASA's Global Precipitation Measurement mission Microwave Imager (GPM GMI) data, as displayed within the AWIPS decision support system used by NOAA/National Weather Service partners.
- NASA's GPM GMI provides passive microwave brightness temperatures useful for displaying cyclone structure, particularly when able to see through overlying cirrus to the center of circulation and spiraling rain bands.
- In addition, cross-calibration of other passive microwave brightness temperatures are made available from the Precipitation Processing System, along with estimates of rainfall from the Integrated Multi-satellitE Retrievals for GPM (IMERG) product.

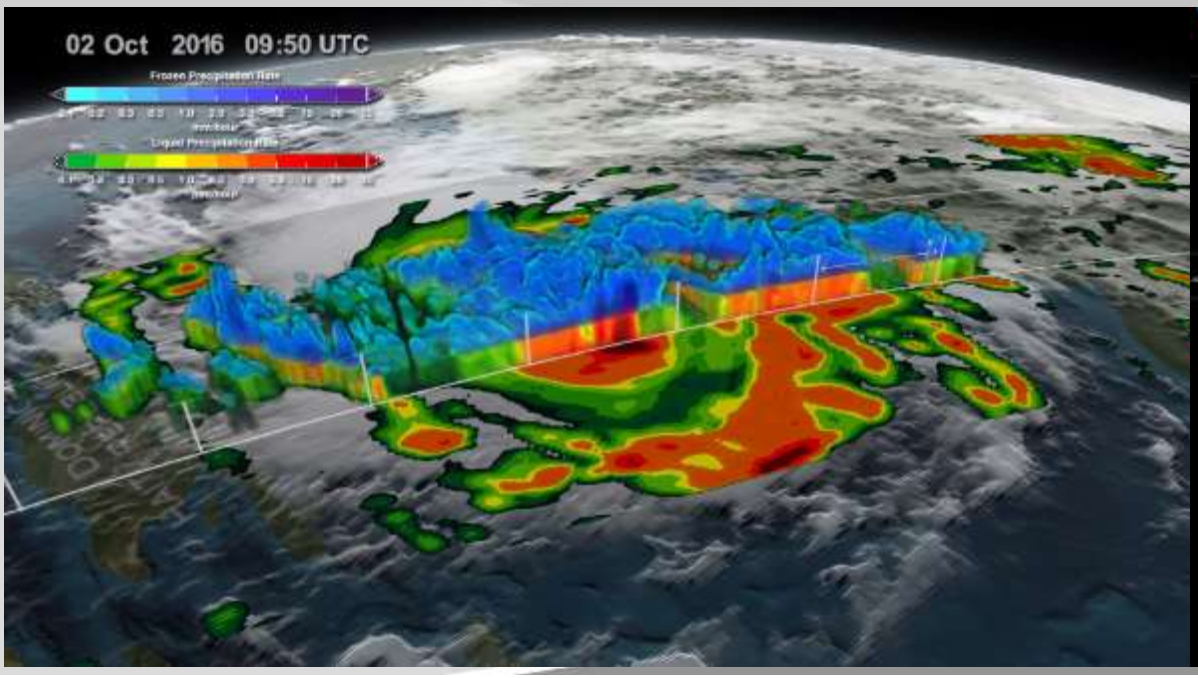


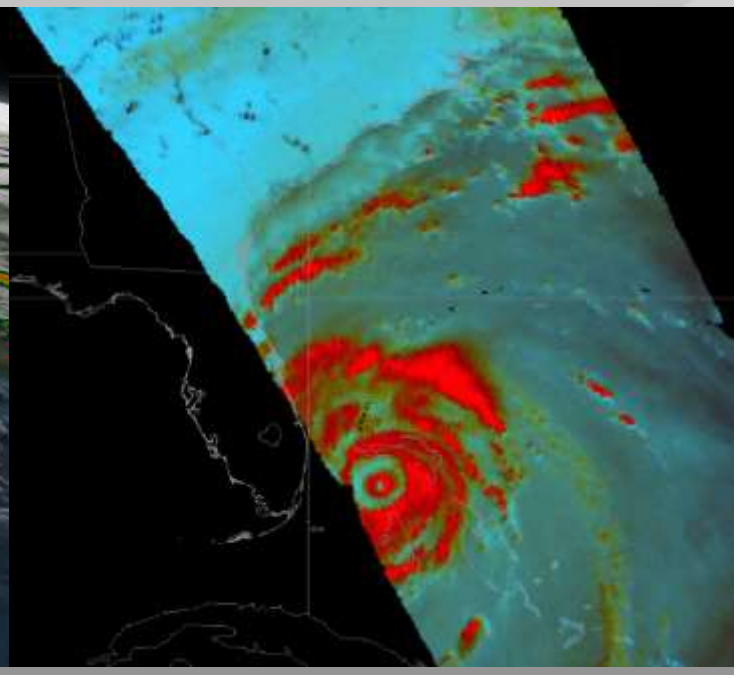
Hurricane Matthew approaches Florida on at (top) 9 and (bottom) 19 UTC on October 6, with passive microwave brightness temperatures observed from the GPM GMI; data provided to NOAA/NWS/National Hurricane Center

GPM observes Hurricane Matthew's rapid intensification and eyewall replacement



- GPM observed intense rainfall (left) as Matthew battered Hispaniola and Cuba
- On Oct. 2 (bottom left) GPM Core Observatory viewed a newly intensified Cat 4 storm south of Haiti, showing strong convection and heavy rainfall in the eye wall and rain bands
- GPM's Microwave Imager (bottom right) observed the storm going through eye wall replacement before impacting Florida as a Cat. 3. This data was provided to FEMA and NWS Offices for situational awareness

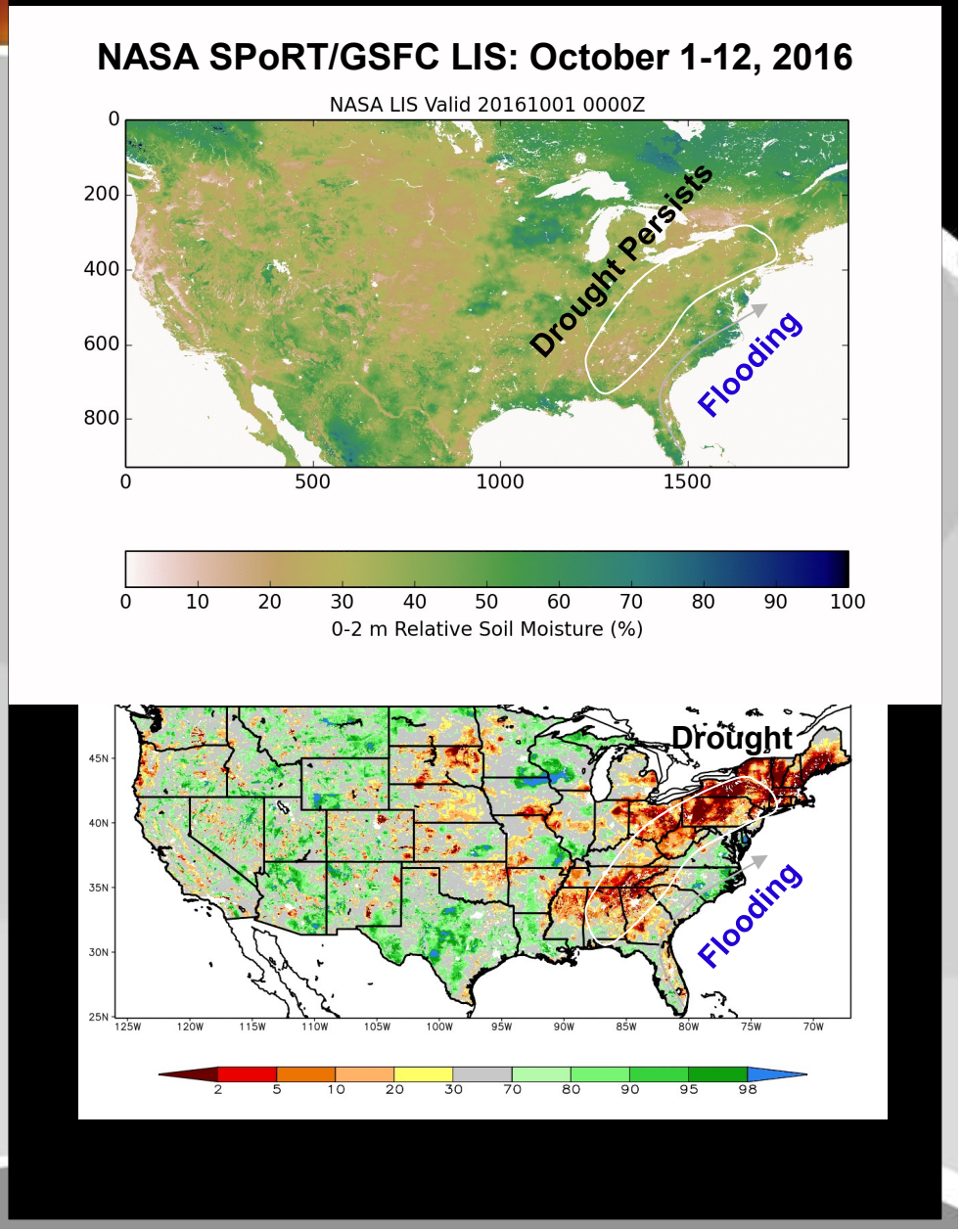




Soil Moisture Mapping of Matthew

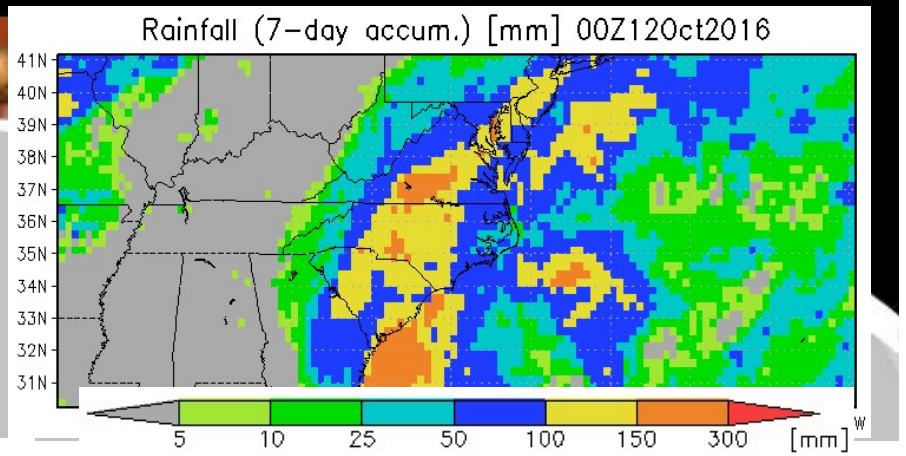
- NASA's Land Information System (LIS) assisted NOAA/NWS partners with:
  - Mapping high soil moisture content prior to Matthew and heavy rainfall events where flooding is likely
  - Mapping dry soils to understand the extent of and change in drought, used by NWS partners to inform updates to the U.S. Drought Monitor
  - Understanding how current conditions relate to 30-year climatology
- LIS outputs were shared with NOAA/NWS and USGS/HDDS during their Hurricane Matthew response.
- New application partners identified (U.S. Forest Service); other spinoffs to follow, including power-outage prediction when combined with predicted wind speeds, duration, and extent.

(Top) (0-2 m) soil moisture (0-100%) pre- and post-Matthew. (Bottom) Soil moisture compared to 30-year climatology (percentiles). Pre-Matthew soils were saturated in the eastern Carolinas and drier in eastern Florida; high soil moisture remains.

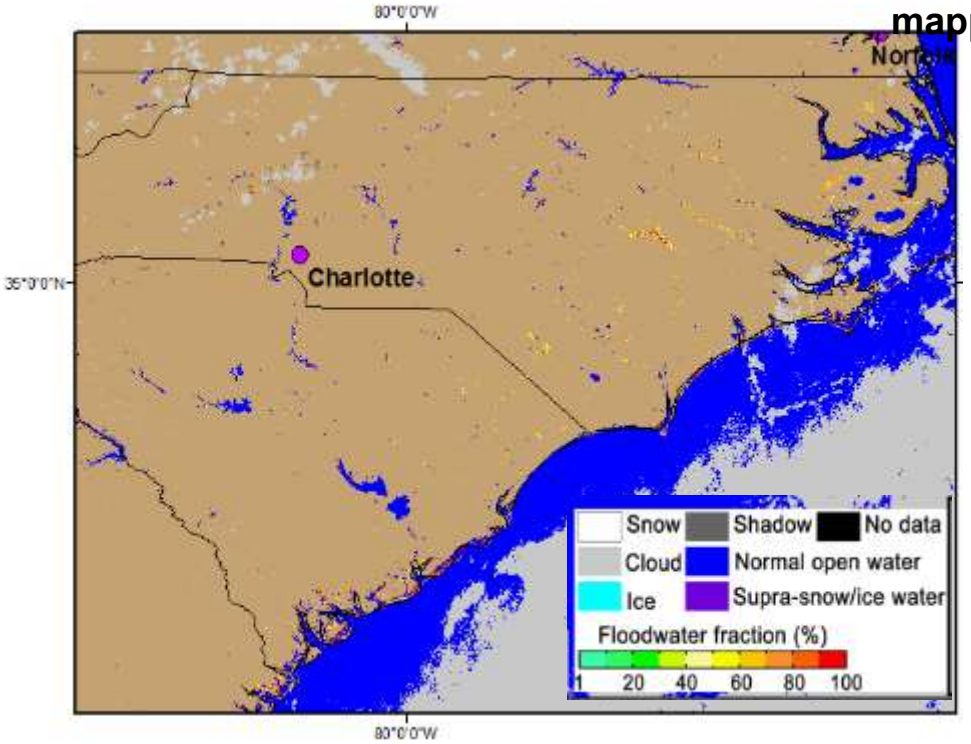


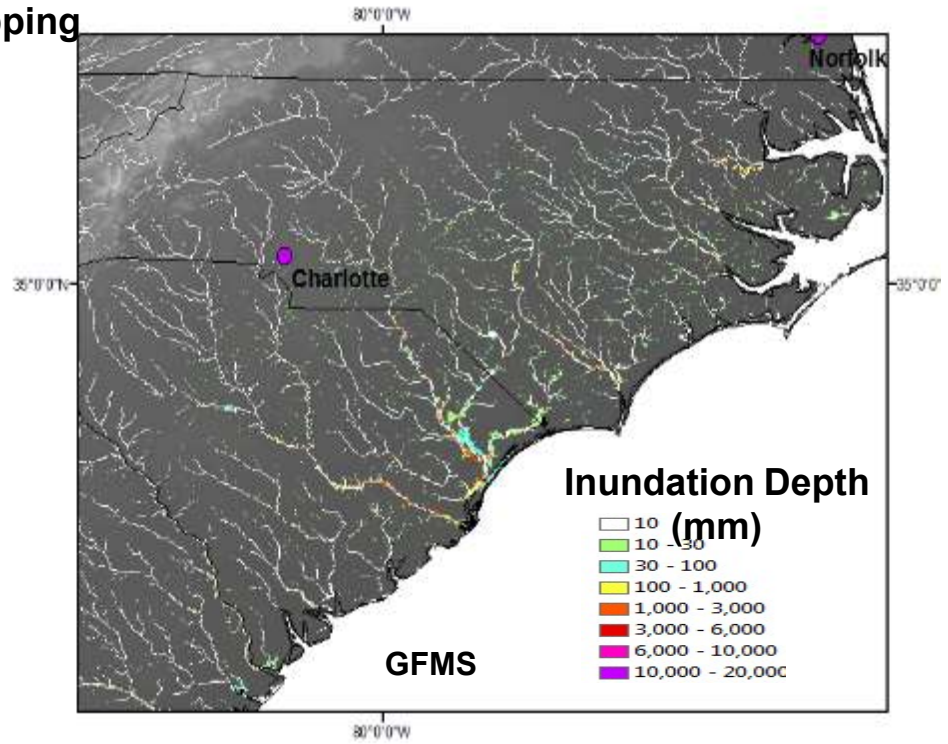
Flood products provided for Hurricane Matthew Response

- The Global Flood Monitoring System provided inundation estimates, flood intensity/detection, and forecasts for Matthew (bottom right)
- GMU used VIIRS to map estimated inundation area follow Matthew's passage (bottom left)



Inundation on same time: Oct. UTC 18:00: Global Flood Modeling System vs. GMU's VIIRS mapping



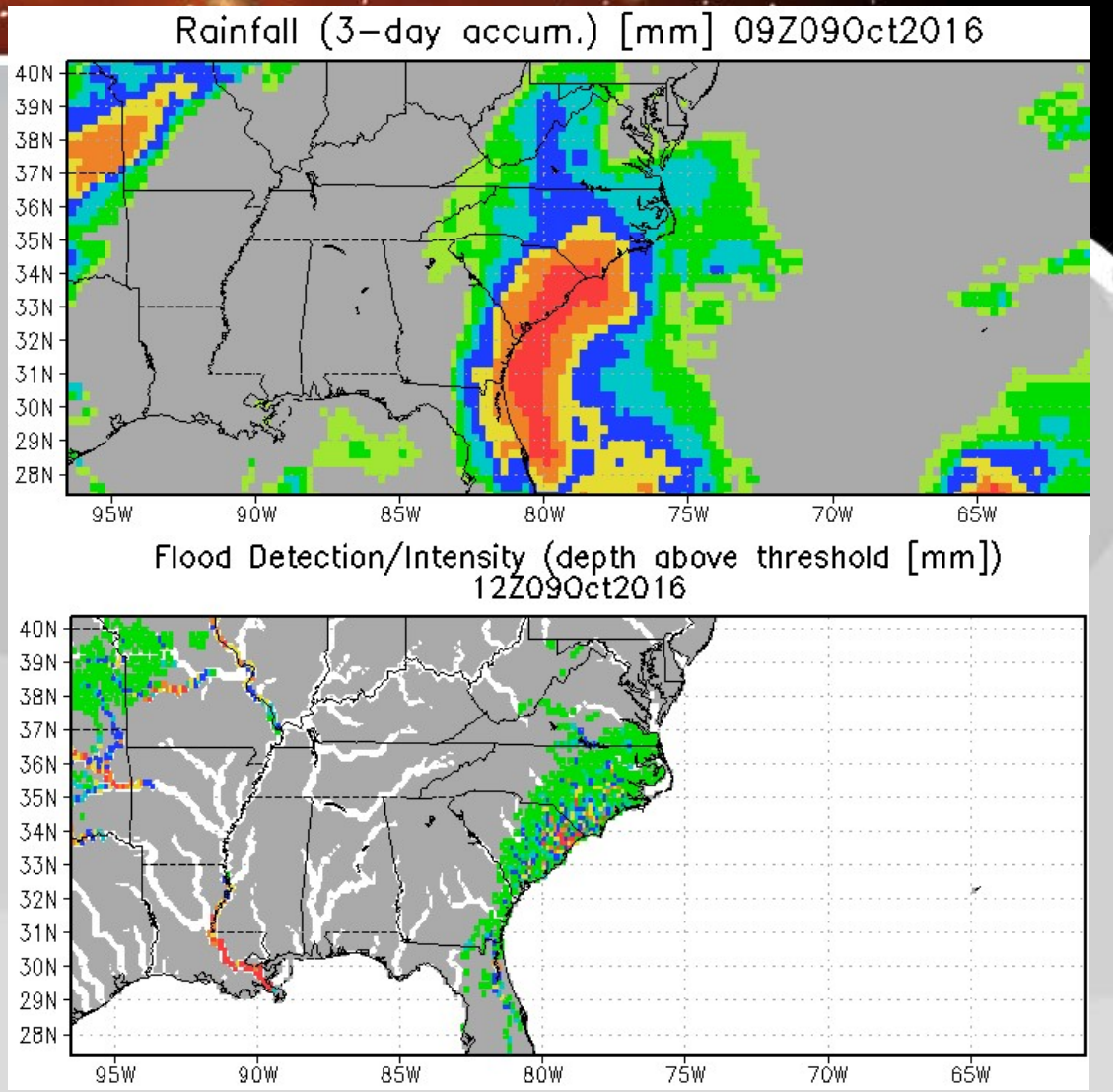


Samei Li, Donglian Sun/GMU

Huan Wu, Bob Adler/UMD

Heavy Rainfall and Flood Prediction

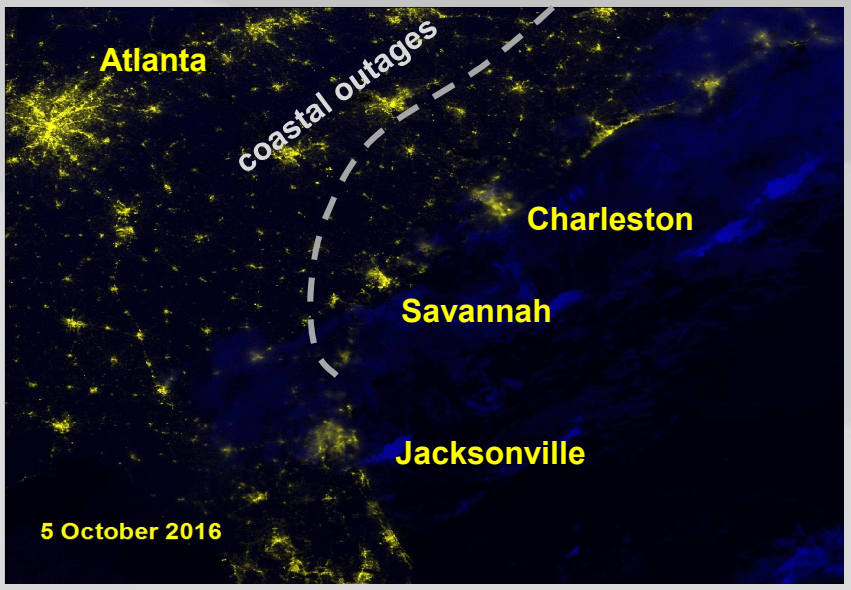
- Extensive inland flooding was widely predicted as a result of extremely heavy rains inland of Matthew's trajectory up the eastern seaboard.
- The Global Flood Monitoring project used NASA GEOS-5 model simulations of precipitation, combined with streamflow and flood predictions to map areas of likely flooding in eastern North Carolina, South Carolina, coastal Georgia, and northeastern Florida.
- These areas experienced record rainfall with Matthew, resulting in several days of near or record flooding in the areas highlighted by the Global Flood Monitoring project's flood predictions.



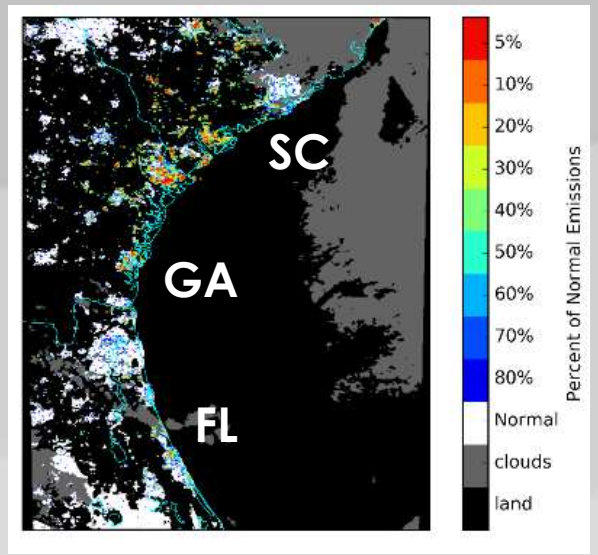
NASA GEOS-5 48-hour rainfall prediction (top) and associated prediction of streamflow and resulting flooding associated with Matthew's coastal impacts on the Carolinas and coastal Georgia.

Power Outages with S-NPP VIIRS

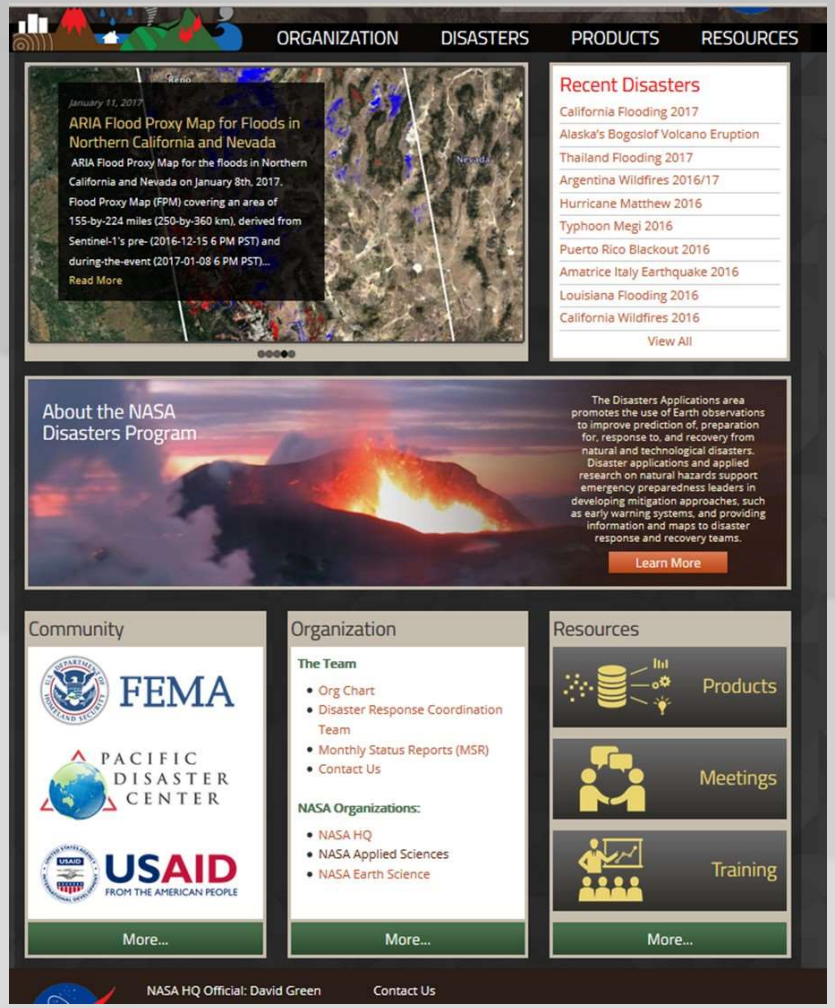
- Collaborations between NASA Goddard, their Direct Readout Laboratory, and MSFC/SPoRT have contributed pre- and post-event light comparisons using VIIRS Day-Night Band emissions and gridded products that incorporate corrections for moonlight.
- This approach allows for analyzing changes between pre- and post-event scenes and identifying missing or reduced lights due to power outages and other impacts from Hurricane Matthew.
- Products provided to FEMA, with future goals of reduced latency and automation.



Animation of change **in lights pre- and post-event; lights here are shown in yellow, and pre- or post-event cloud cover in blue.**



Comparison of pre- (“normal”) and post-event light emission along the southeastern coast following Hurricane Matthew, on October 9.



Dr. David Green
Disaster Response
Program Manager

Office: 202-358-0032
Mobile: 202-748-2875
David.S.Green@nasa.gov

Response: **https://disasters.nasa.gov/**

Program: **http://appliedsciences.nasa.gov/programs/disasters-program**