NASA Disasters Program: A Partner for Coastal Disaster Response, Resiliency, and Risk Reduction

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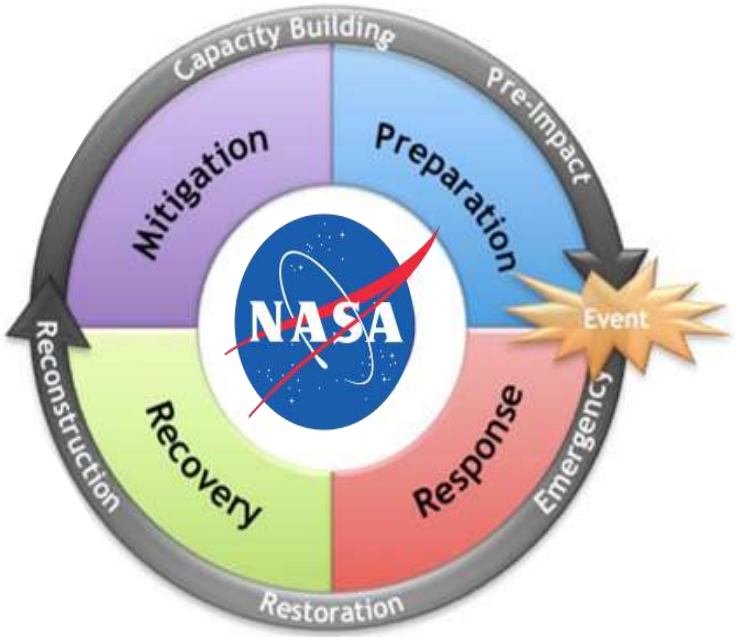
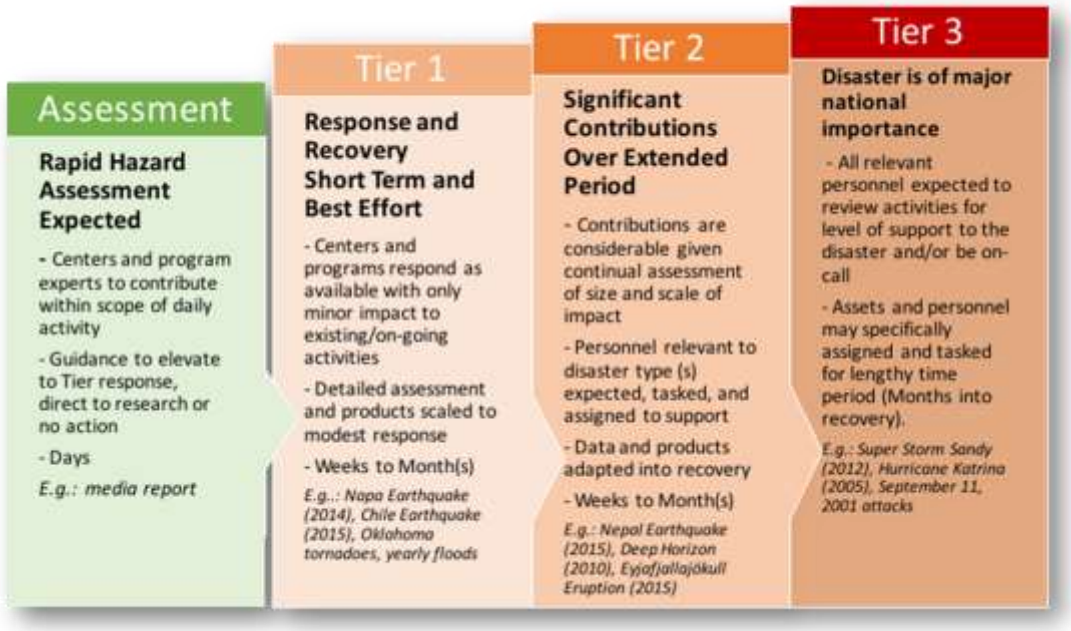
17th Annual Climate Prediction Applications Science Workshop



Disasters Program Mission and Goals

- Program Mission: The Disasters Program mission is to use Earth observation to inform disaster risk reduction and resilience across the disaster cycle from local to global scales.

- Program Goals:
  - Harness NASA Capabilities for Disaster Risk Reduction (DRR) and resilience.
  - Engage stakeholders in the use of Earth Observations (EO) throughout the disaster lifecycle.
  - Demonstrate the value and impact of EO to support decision making and actions.
  - Grow as a trusted source for delivering useful results.



Communities at Intensive Risk

Mid-Atlantic Resiliency Demonstration Study

A. Molthan[1], D. Loftis[2], H. Wang[2], D. Forrest[2], J. Srikishen[3], D. Sun[4], D. Bekaert[5], S. Cohen[6], T. Allen[7], B. Hamlington[7], W. Moore[8] , L. Rogers[9], D. Borges[9], W. Ball[9], J. Murray[9], D. Green[10]

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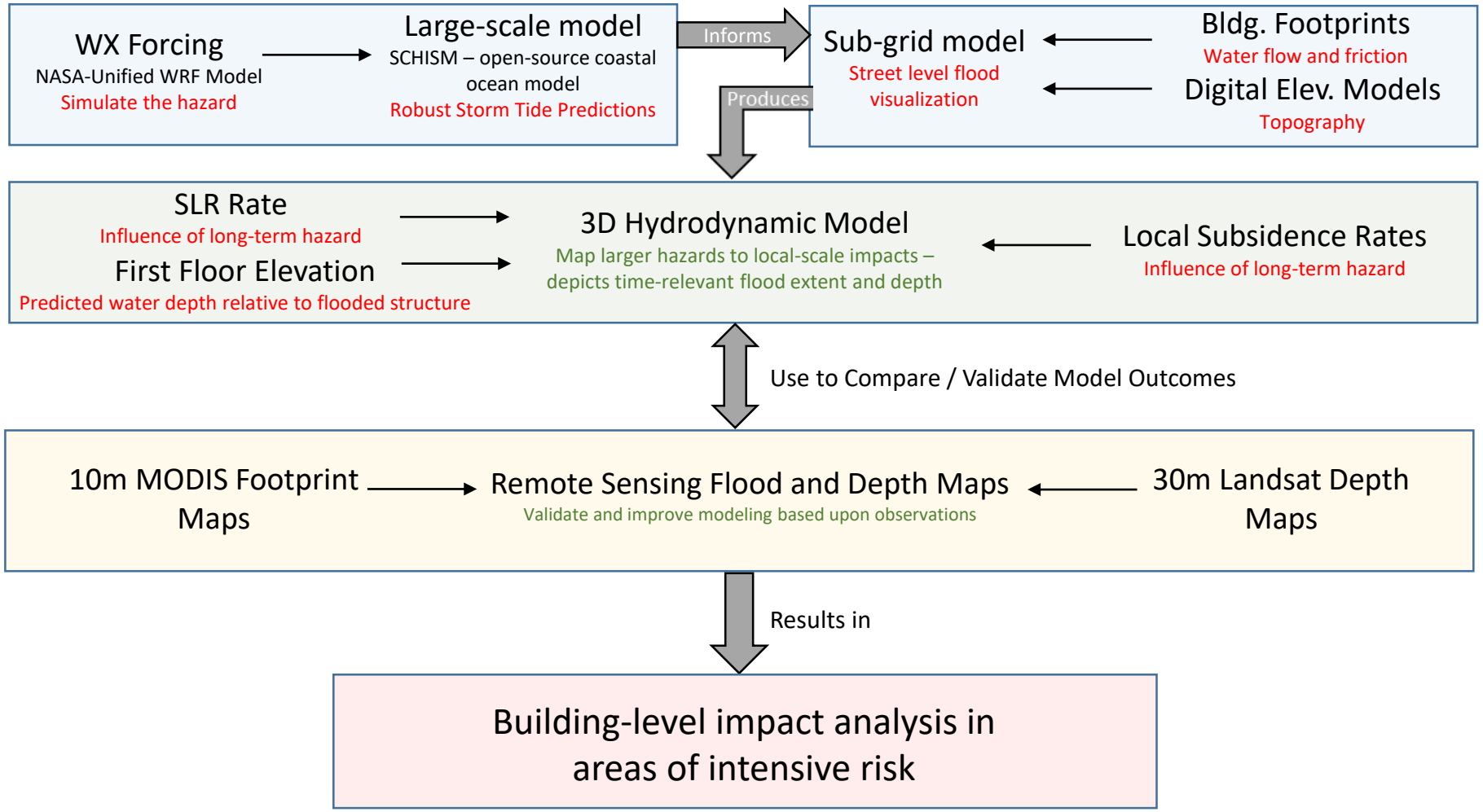
Background

- In FY17, NASA's Applied Sciences: Disasters Program began a small pilot project titled "***Mid-Atlantic Resiliency Demonstration Study, Communities at Intensive Risk***"
- Strategic Goals and Objectives:
  - Demonstrate how coupling diverse models, data and predictions enable us to develop and extend our **collective knowledge** of compounding risk
  - Collaborate with partners to understand their data-driven needs for decision making in coastal communities with intensive risk
  - Demonstrate how various tools, ranging from modeling to remote sensing, can help to identify current and future areas of risk.
  - Engage with key external partners to understand their goals for improving disaster resilience and participate as a key collaborator.
- Focus:
  - Holistic, interdisciplinary research and integrated application outcomes focused on improving resilience for coastal communities.
- Areas of Interest
  - Portsmouth, VA
  - Norfolk, VA
  - Pamlico County, NC

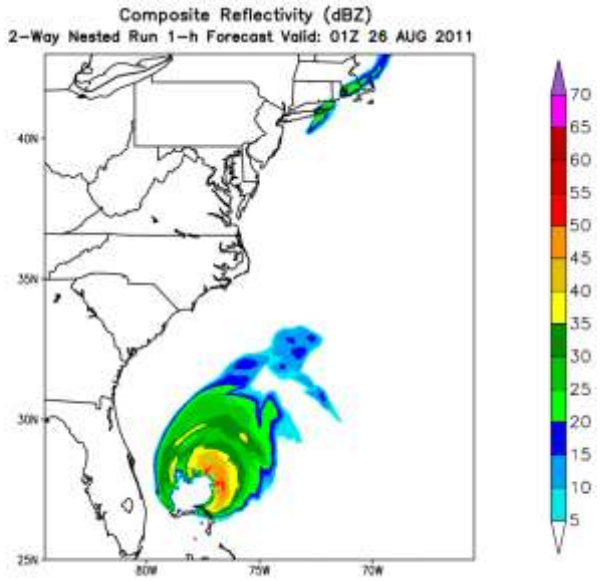
Technical Components

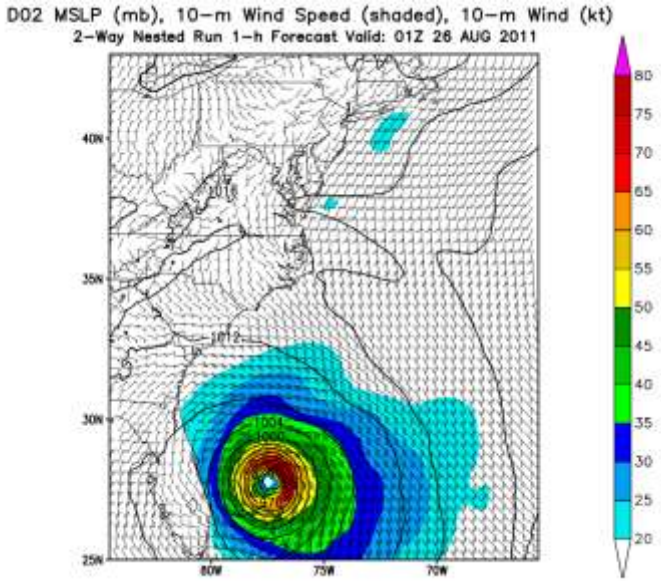


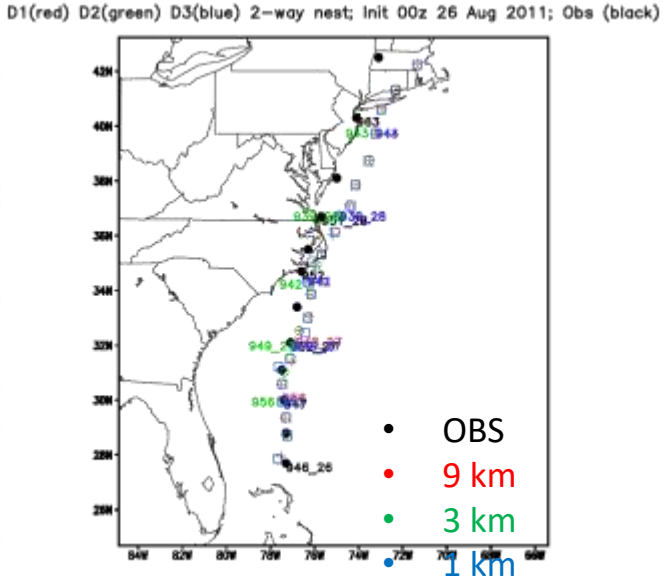
2011 Irene Simulations

J. Case, J. Srikishen, A. Molthan, NASA Marshall

- Using the NASA-Unified WRF Model to create a reanalysis of an Irene-like storm, based upon GFS analysis data available from 2011.







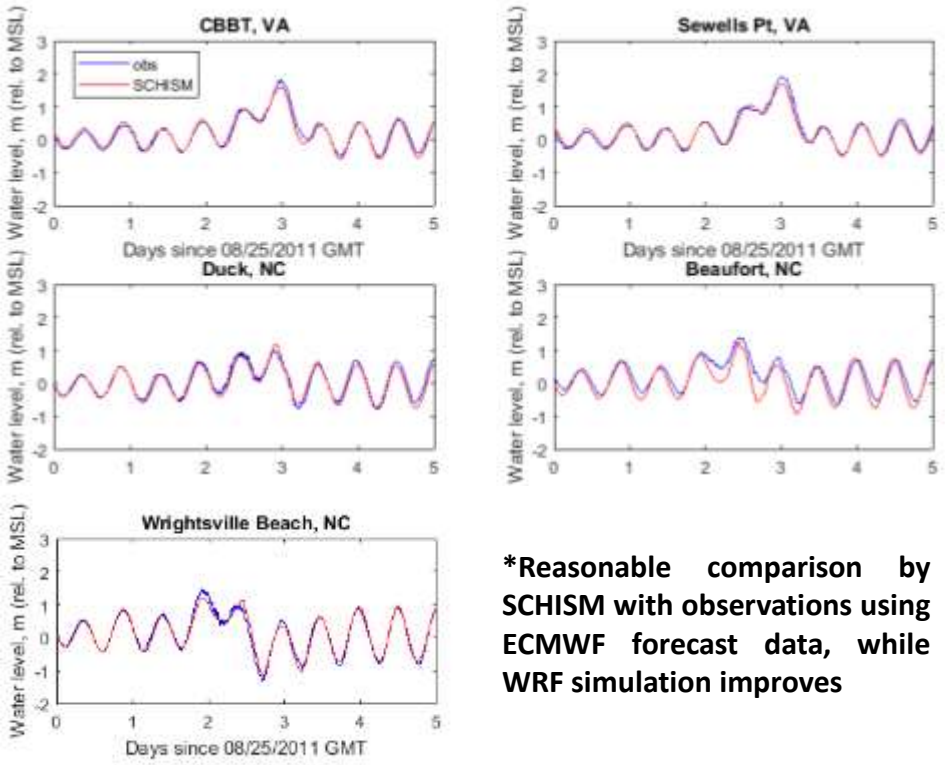
- Early issues with simulating the storm from GFS analyses: landfall was too early, storm was too intense. Exploring solutions through various initialization times, parameterizations, TC initial conditions, perhaps switch to HWRF.
- For exploratory work and fitting to other models, track and timing are reasonable for approach to NC/VA. ECMWF also provides good Irene simulations

Large-Scale Storm Tide Modeling

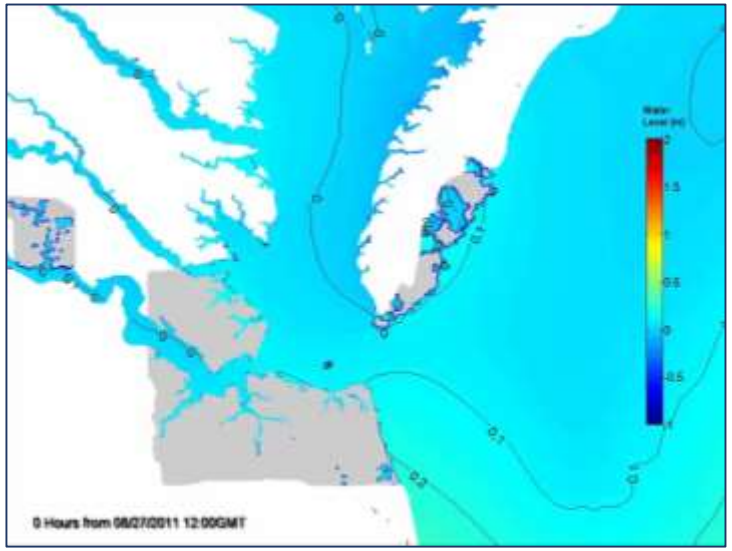
Z. Liu, H. Wang, Virginia Institute of Marine Science

- **SCHISM** (Semi-implicit, Cross-scale, Hydro-science Integrated System Model)
  - Operationally tested and proven (NOAA, DWR, CWB…)

SCHISM Simulation Results Driven with ECMWF Wind and Pressure Data



***Reasonable comparison by SCHISM with observations using ECMWF forecast data, while WRF simulation improves**



Animation of Model Output near Chesapeake Bay

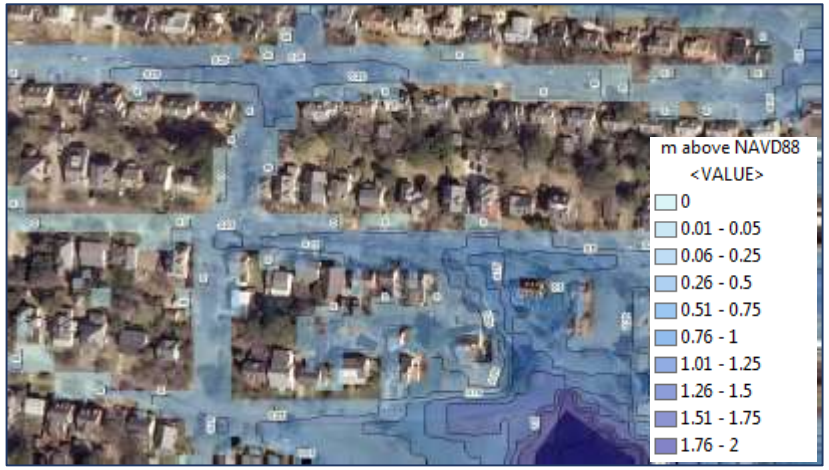
Goal: Establish confidence in model capabilities for predicting coastal hazards when combined with supporting numerical weather prediction inputs, then explore with varying intensity and other types of coastal change (sea level, subsidence).

Street-Level Flood Modeling

J.D. Loftis, Virginia Institute of Marine Science

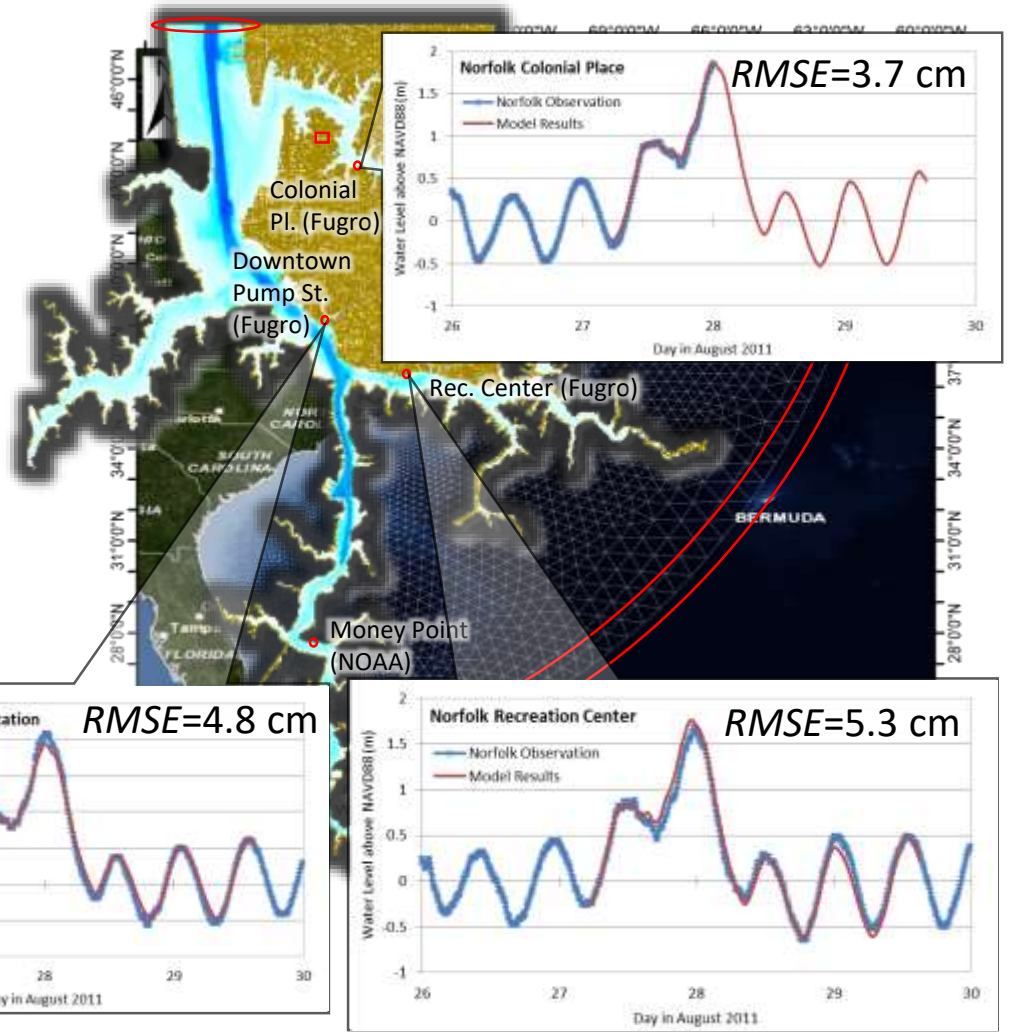
- Driven with water levels and atmospheric forecasts from Large-Scale SCHISM model
- Compares well with local sensor data

2011 Hurricane Irene Max. Flood Extent Forecast: Contour Map in Norfolk's Larchmont Neighborhood



Goal: Develop dynamic flood forecast maps to effectively and quickly communicate inundation risk; further aid prediction of long-term coastal storm hazards with sea level rise & subsidence predictions.

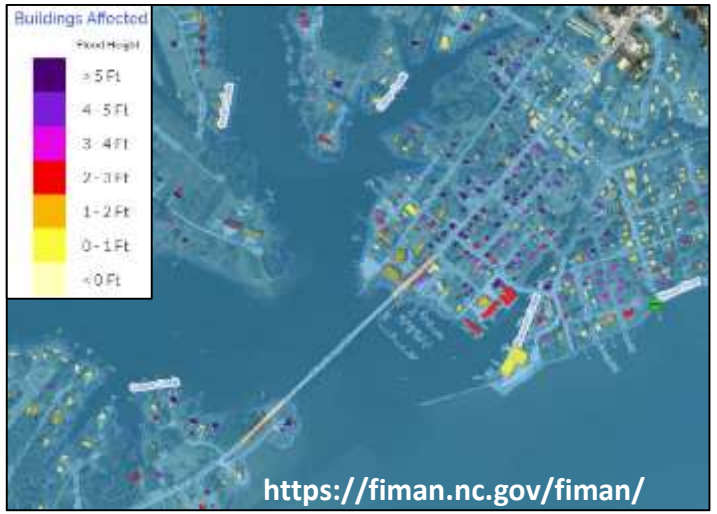
SCHISM Model Domain

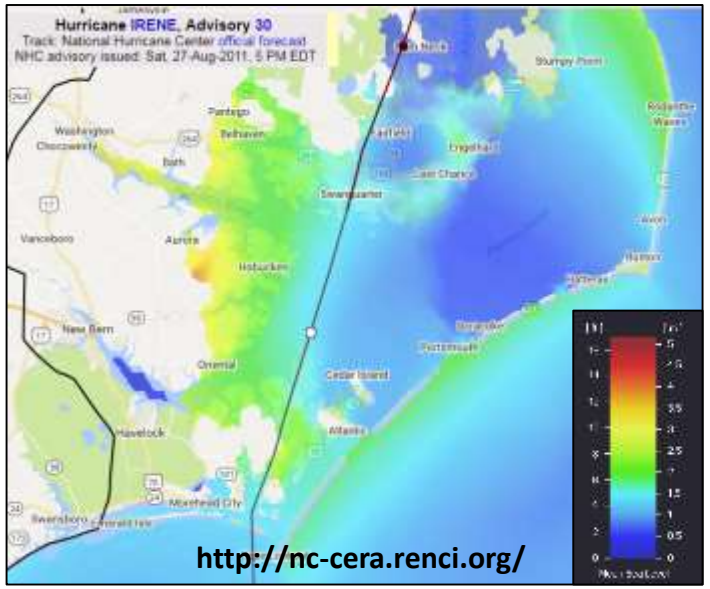


Geospatial Integration for Hurricane Irene Reanalysis

Dr. Tom Allen, Geography Program and
Commonwealth Center for Recurrent Flooding Resiliency (CCRFR)
Old Dominion University, Norfolk, VA

- Demonstrate geospatial analysis and integration for flood impacts from storm surge models, SAR, and LiDAR
- Source and provide supporting data for Irene
  - NC Flood Inundation Mapping and Alert Network
  - High Water Marks (NWS and USGS)
  - Dasymetric population demographics
  - NHC Hurricane forecast track, cone, watches, warnings, and surges
  - SLOSH surge MOMs and MEOWS, NC-CERA/Renci ADCIRC
- Engage stakeholders for needs and applications
  - NWS, cities, and Hampton Roads Planning District Commission
  - Hampton Roads Coastal Resiliency Working Group
  - Leverage modeling and remote sensing for time-dependent planning, response, and resiliency
- Develop lessons learned, uncertainties, and improvements for future research
  - Sentinel, NISAR, other platforms and data sets

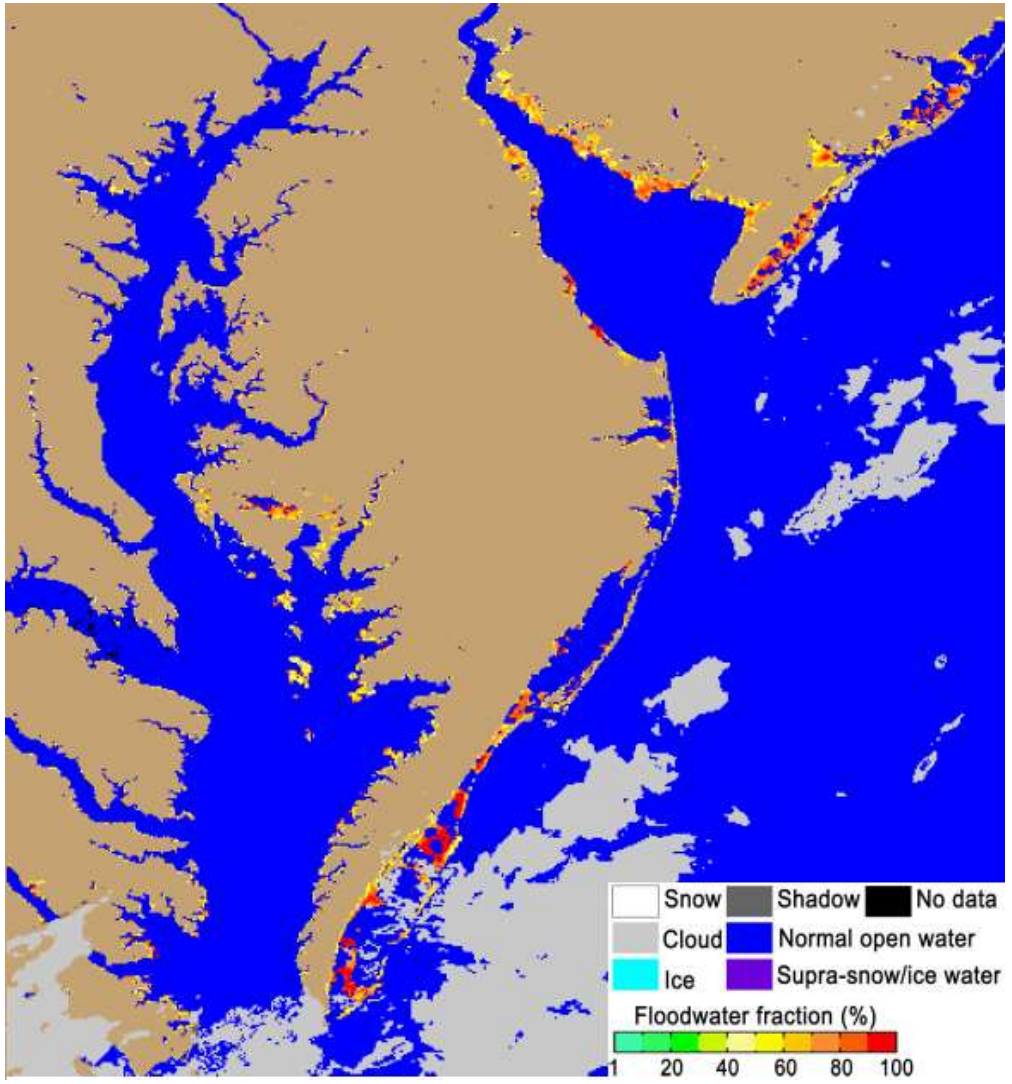




Revisiting Flood Maps with new VIIRS Flood Mapping Capability

Dr. Lillian Sun, George Mason University

- Team from George Mason University is revisiting MODIS and Landsat remote sensing adopting new techniques developed for VIIRS:
    - Reduced impact of terrain shadows, cloud shadows, and other potential errors



Improving Access to Flood Mapping

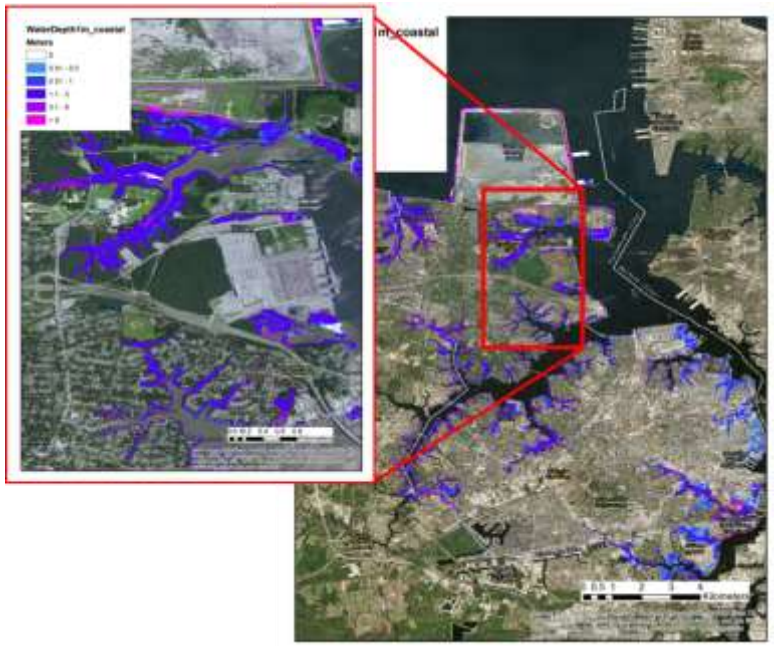
Dr. W.B. Moore, Hampton University

- Incorporating VIIRS algorithm for processing of NRT MODIS and other imagery
    - Share with partners to improve flood mapping capabilities from NASA MODIS sensors

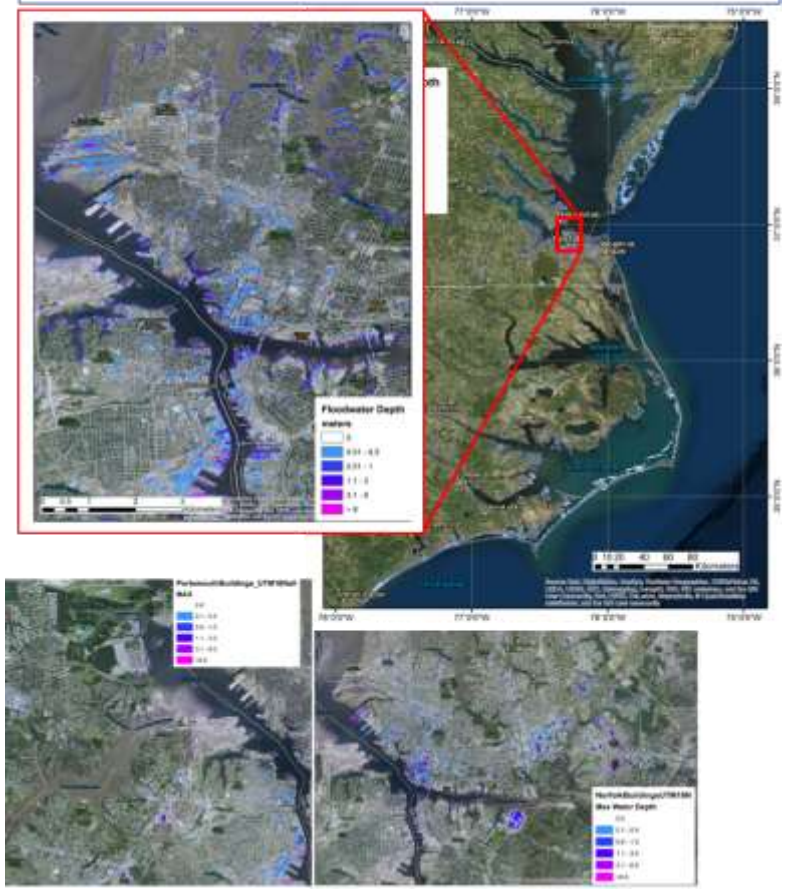
Floodwater Depth Estimates from Remote Sensing of Flood Water

Dr. Sagy Cohen, Surface Dynamics Modeling Lab,
University of Alabama

- Estimate floodwater depth based on remote sensing inundation maps and a DEM:
  - *Landsat imagery classification and 10m NED DEM*
- Assess accuracy and feasibility of the methodology for coastal flooding:
  - *Hydrodynamic model flood extent and 1m LiDAR*



Floodwater Depth Estimation Tool (**FwDET**; Cohen et al. 2017 JAWRA) calculates water depths based solely on an inundation polygon (primarily from Remote Sensing) and a DEM.



Summary

- The NASA Applied Sciences: Disasters Program has kicked off a pilot project as "***Mid-Atlantic Resiliency Demonstration Study, Communities at Intensive Risk"*** in FY17 and FY18
- Efforts focus on a holistic, interdisciplinary approach to integrate a full suite of capabilities from numerical weather prediction, tide and surge modeling at high spatial resolution and urban/neighborhood scales, and remote sensing capabilities for water detection and depth estimation.
- Future efforts:
  - Partner with Federal Agencies, academia professional societies to complement and augment ongoing work using **Earth observations unique to NASA**
  - **Translate hazards to risk** in order to understand local and regional impacts and **minimize vulnerability**

NASA Disaster Programs
Response Efforts

Response and Engagement Timeline: Hurricane Florence

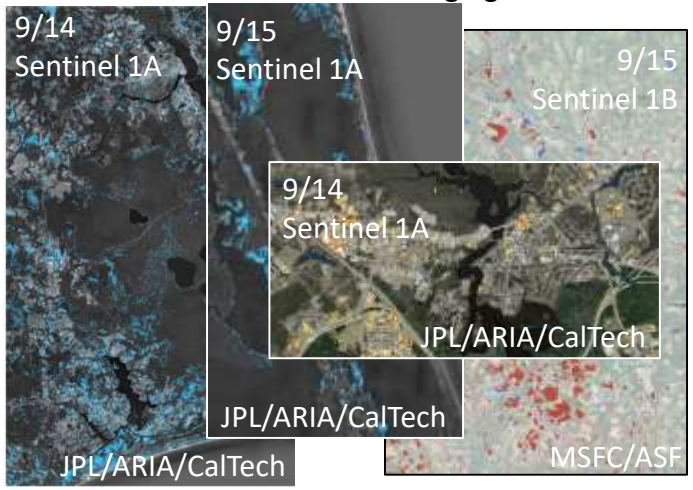
Forecasts for Florence identify likely, significant impacts to the southeastern U.S., and NASA team activates for coordination calls, product generation, and end-user engagement

Integrated Sharing of Data via Esri Services

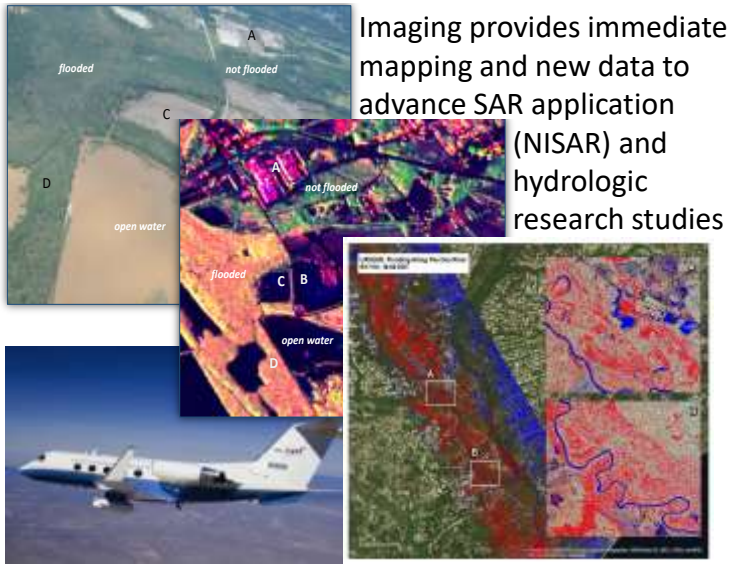
Sharing of imagery, products, and training through uniform services to improve integration

Photos from the ISS demonstrate the storm's intimidating size and intensity, capturing the attention of the public and media

Flood Mapping: Team members generate flood and damage proxy maps via ESA and International Charter contributions to SAR imaging



UAVSAR Flights Support Research and Response Efforts



Imaging provides immediate mapping and new data to advance SAR application (NISAR) and hydrologic research studies

9/18: 10 9/19: 9 9/20: 8 9/22: 8 9/23: 8 UAVSAR Collections

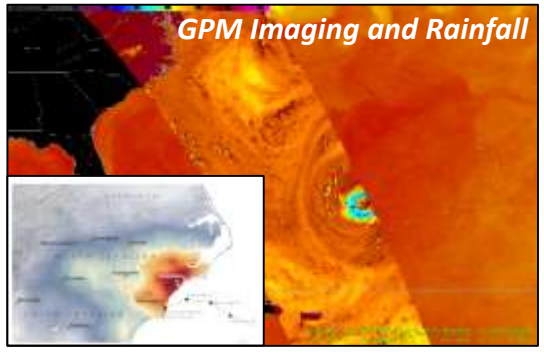
NASA Response Tier | 0 | **Tier 1: 9/10** | **Tier 2: 9/14** | 9/17: UAVSAR Arrives + 2 Legs | **Tier 1: 9/24** | 0

Day 1: Sept 9 **Day 20: Sept 28**

9/13 – NASA Team Member Supports at FEMA HQ – 9/20
9/14 – UAVSAR and Team Receive FEMA Mission Assignment
9/17 – NASA UAVSAR Flights to Support Science and Response – 9/24

Team Coordination:
Daily calls begin to coordinate NASA team:
- Flood Mapping
- Other Products
- UAVSAR

Pre-Existing Partners
- FEMA, USFS, NOAA/NWS and NWC, USGS, National Guard,
- Research/Academia

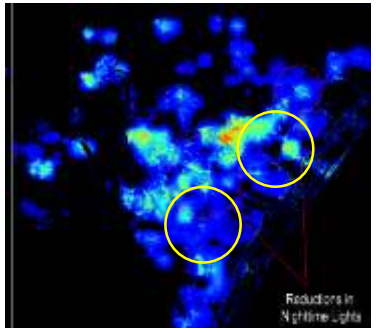


Monitoring the Storm: NASA's SPoRT Center, via R&A, ensures mission data support operational forecasting

Global Flood Monitoring System estimates extent of inundation

Mapping Floods as Skies Clear: Clear skies and views from MODIS/Landsat

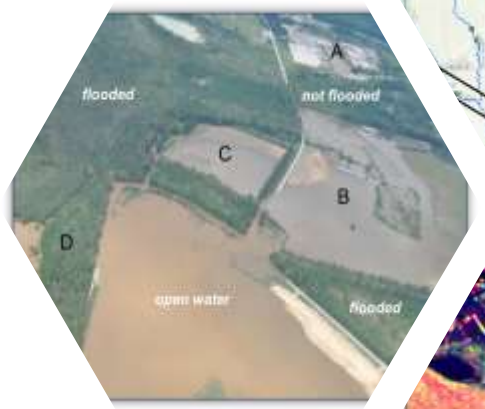
NASA Black Marble HD
Black Marble HD: Captures lights missing in coastal Wilmington, NC



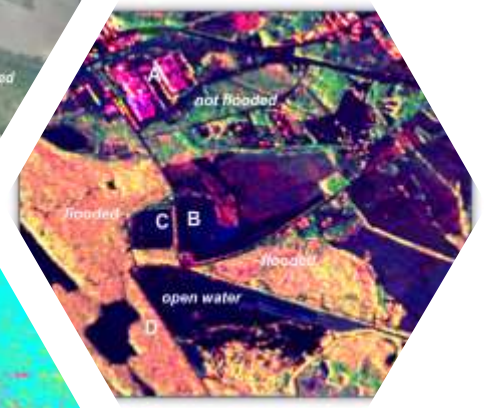
Decreased illumination compared to pre-event composite

Assigned: 9/14

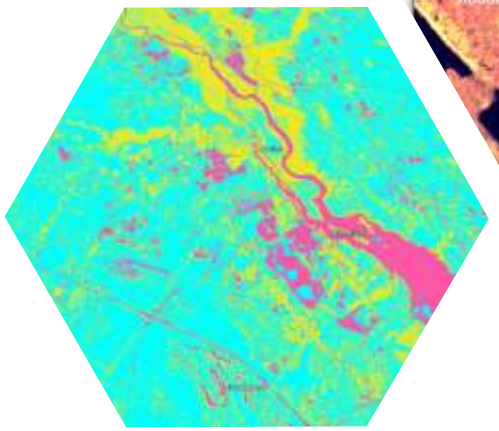
Daily Coordination



Observed Flooding



UAVSAR Signatures



Mapped Information

UAVSAR Mission Assignment

- FEMA requested mission assignment of the Gulfstream-III and UAVSAR instrument for repeat collection of L-band SAR over the affected areas
- Daily coordination calls targeted UAVSAR collections where significant river flooding was ongoing or expected, and where populations were at risk from rising flood waters
- UAVSAR collections supported rapid mapping of flood extent through false color composites and extraction of visual signatures
- Mission data were also collected to support an EPSCoR* research activity examining predictions for the Congaree River
- UAVSAR provided immediate value in near-term mapping and longer-term value through repeated collections in flooded rivers and basins that will support further study of rivers, hydrology, streamflow, and inundation
- Collections of L-band and polarized SAR provide new data sets to build experience and applications around the NASA-ISRO SAR (NISAR) mission expected in 2022

* Experimental Program to Stimulate Competitive Research (EPSCoR)

Contact Information

- Dr. David Green, Program Manager, NASA HQ
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- Jordan Bell, Disaster Response Coordinator, UAH/NASA MSFC
  - jordan.r.bell@nasa.gov

- Program Website: https://disasters.nasa.gov/

- Program's Mapping Portal (GIS): https://maps.disasters.nasa.gov/

Backup Slides

Areas of Interest: Virginia

- Preliminary focus in Virginia based upon previously established partnerships in these areas and significant impacts from past events.

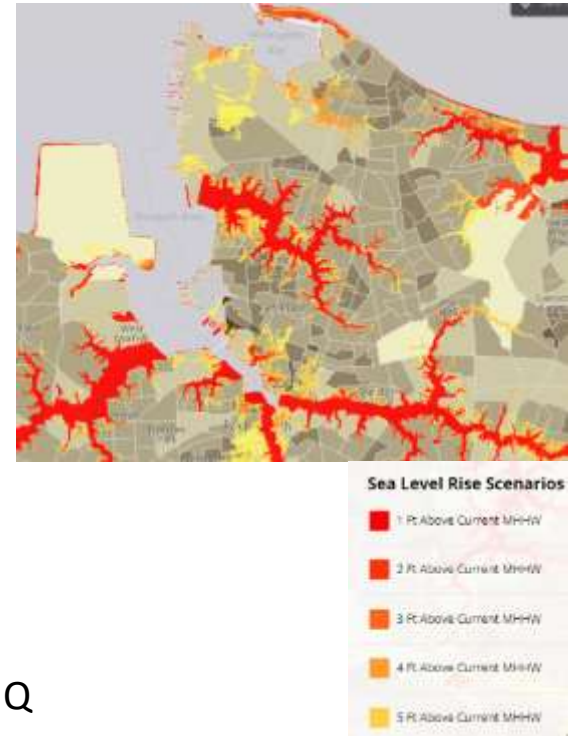
Portsmouth, VA

- Craney Island Naval Supply Center
- Norfolk Naval Shipyard

Norfolk, VA

- Naval Station Norfolk
- NATO Strategic Command HQ

Sea Level Rise Scenarios

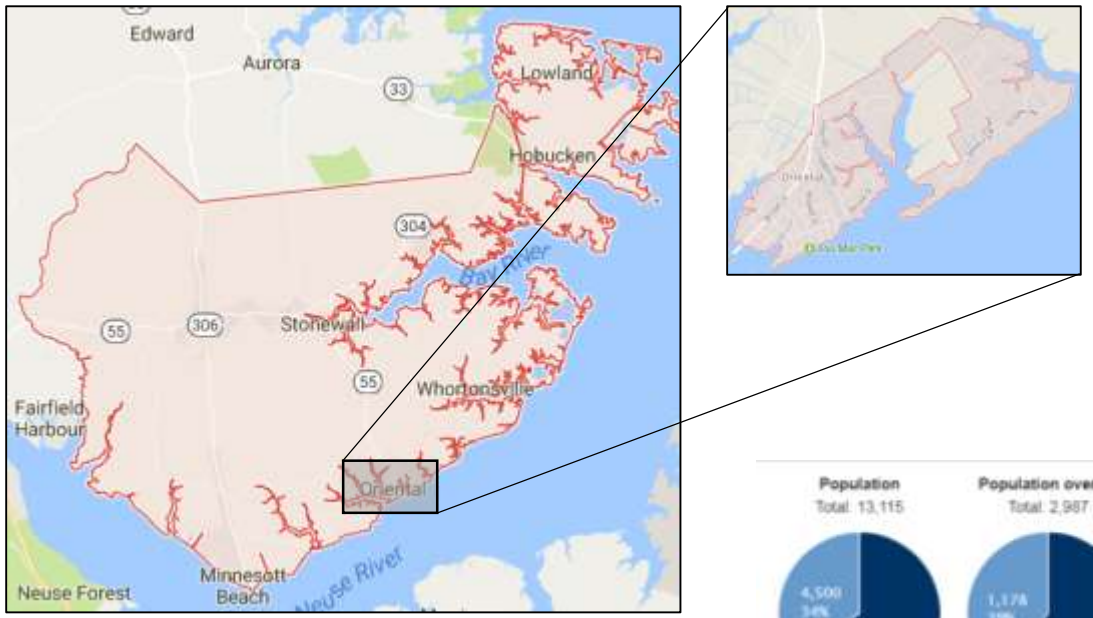


https://coast.noaa.gov/floodexposure

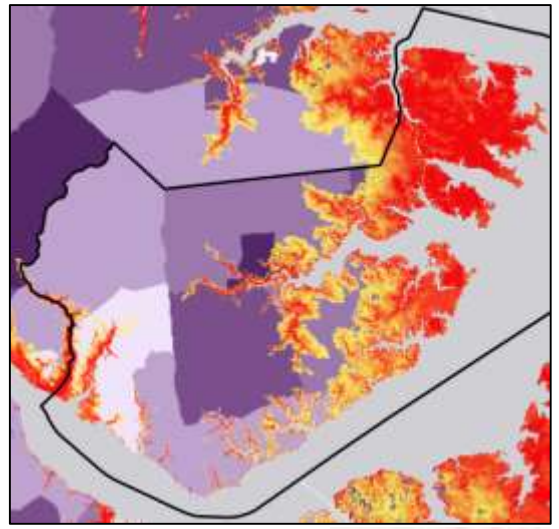
Areas of Interest: N. Carolina

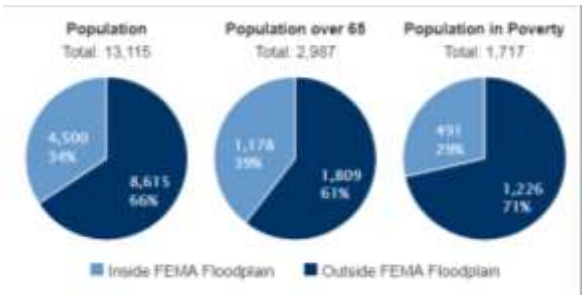
- Preliminary focus in N. Carolina focused on partnerships as well as unique access to high-resolution data for analysis.

Pamlico County, NC



Sea Level Rise Scenarios





https://coast.noaa.gov/floodexposure

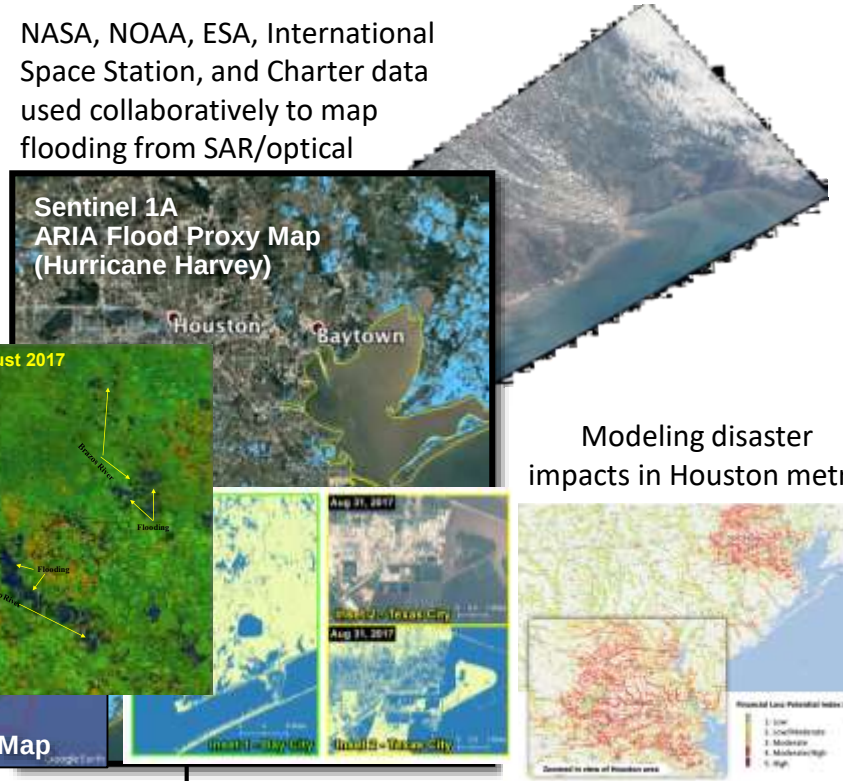
NASA Response and Engagement Timeline

Hurricane Harvey (Aug-Sept 2017)

NASA's Earth Science DISASTERS

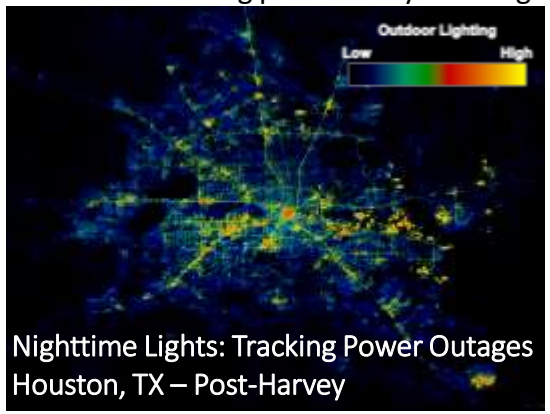
Forecasts for Harvey identify impacts to U.S. mainland, NASA team activates for coordination calls, product generation, and end-user engagement

NASA, NOAA, ESA, International Space Station, and Charter data used collaboratively to map flooding from SAR/optical



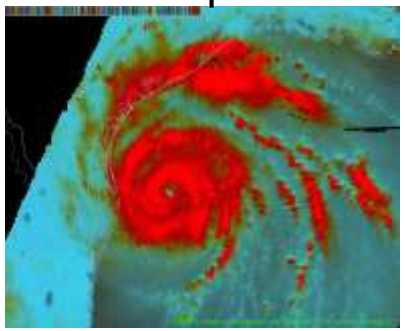
Modeling disaster impacts in Houston metro

Use of NASA Black Marble HD product to explore power outages during post-Harvey flooding



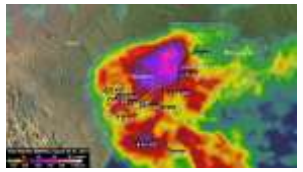
NASA Response Tier	0	1	[Numerous Flood Maps from NASA Teams →	2	1	0
	Day 1 August 23	Day 4 August 27	Day 6 August 27 / Day 7 August 28 / Day 9 August 30 / Day 10 August 31	Day 11 September 1	←UAVSAR Flights→	Day 11 September 4 / Day 19 September 9

Daily calls begin to coordinate NASA team in generation of products, engagement of funded PIs, and coordination with federal end user partners including FEMA, USGS, National Guard, and others.



NASA's GPM helps track Harvey with data provided to NOAA/NWS and NHC

NASA team collaborations provide ***over a dozen*** detailed flood maps from SAR used by FEMA's geospatial team



GPM maps the record-setting rainfall in SE Texas from Harvey

NASA provides daily flights of UAVSAR from September 1-4 to rapidly map evolving flood impacts

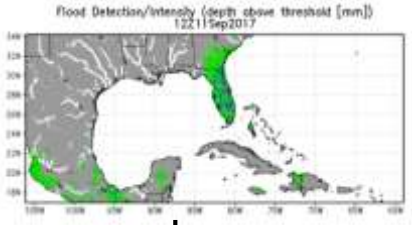
NASA Response and Engagement Timeline

Hurricane Irma (Sept 2017)

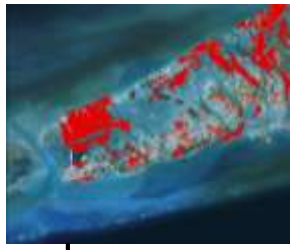
NASA's Earth Science DISASTERS

NASA team initiates response in collaboration with end user partners focused on preparedness and recovery from Hurricane Irma

Partners model likely flood and inundation impacts from Irma's predicted rainfall

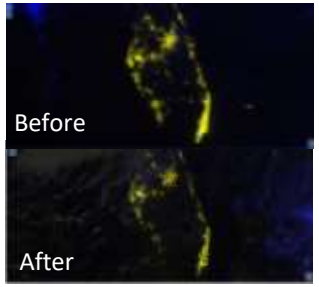


Preliminary mapping of flooding in Key West via ESA Sentinel 1



SAR damage proxy maps generated from ESA Sentinel 1 to identify changes resulting from Irma's winds and flooding

NASA team contributed numerous SAR/optical flood and damage maps to FEMA along with other ESA and commercial partners

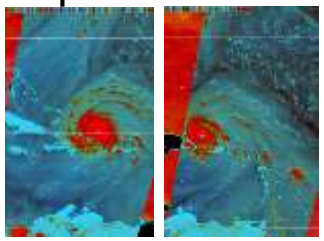


Daily maps of nighttime lights to help understand power loss and recovery

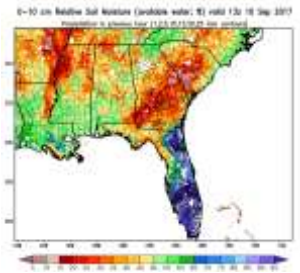
NASA Response Tier 0 | 1 | 0

Day 1 Sept 5 | Day 2 Sept 6 | Day 4 Sept 8 | Day 6 Sept 10 | Day 8 Sept 12 | Day 9 Sept 13 | Day 15 September 19

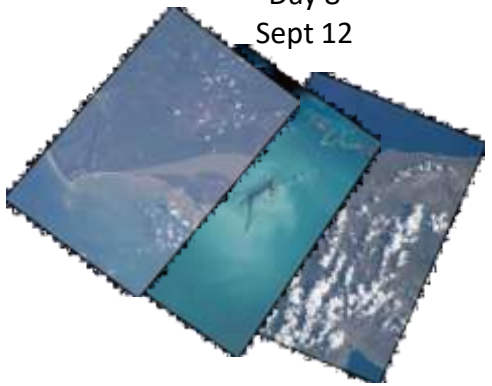
Continuing from Harvey, daily coordination calls and user engagement with partners including FEMA, National Guard, USGS and others



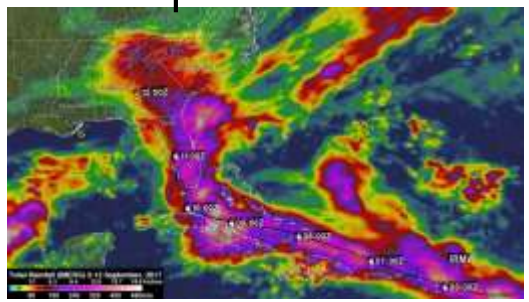
GPM and constellation satellites provide mapping of Irma's track through the Caribbean, data to NOAA/NHC, NRL



Daily NASA LIS captures saturated soils and flooding in FL/SE



ISS astronaut photography provides imagery of impacts in Caribbean/Florida



GPM/IMERG rainfall product measures rainfall across the impacted area

NASA Response and Engagement Timeline

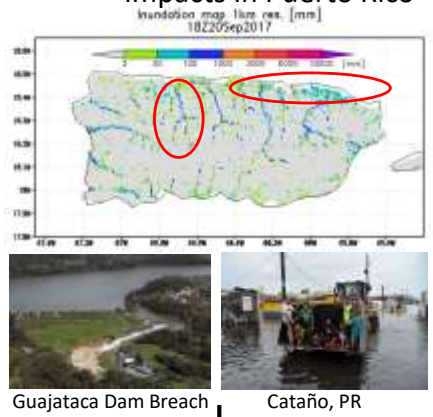
Hurricane Maria (Sept-Oct 2017)

Daily: FEMA Remote Sensing and Geospatial Teams incorporate NASA information into daily briefings and use analysis to understand recovery needs.

NASA's Earth Science DISASTERS

NASA team initiates response in collaboration with end user partners focused on preparedness and recovery from Hurricane Maria

Flood modeling by partners for impacts in Puerto Rico

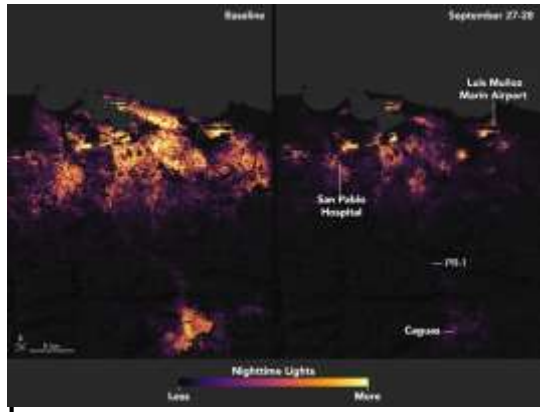


Guajataca Dam Breach

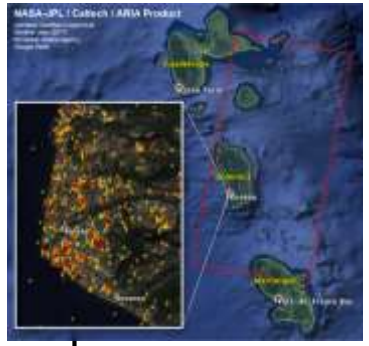
Cataño, PR

ESA Sentinel SAR imaging used to produce damage proxy maps for affected regions in Puerto Rico

NASA Black Marble HD captures Puerto Rico outages, used by partners and major media to keep public informed of local power conditions on neighborhood scales.



Damage proxy maps extended to Dominica using ESA S1 data



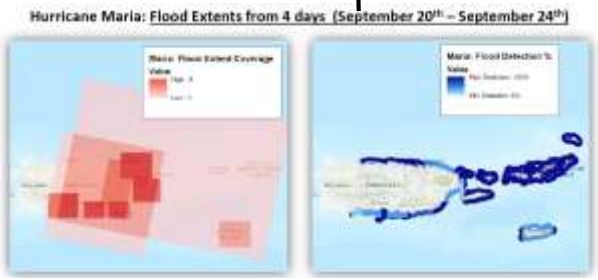
NASA Response Tier **0** → **1** → **Daily Power and Light Analysis w/Black Marble →** **0**

Day 1 Sept 18 | Day 3 Sept 20 | Day 4 Sept 21 | Day 5 Sept 22 | Day 7 Sept 24 | Day 10 Sept 27 | Day 13 Sept 30 | Day 14 Oct 2 | Day 15 Oct 3

Continuing from Irma, daily coordination calls and user engagement with partners including FEMA, National Guard, USGS and others

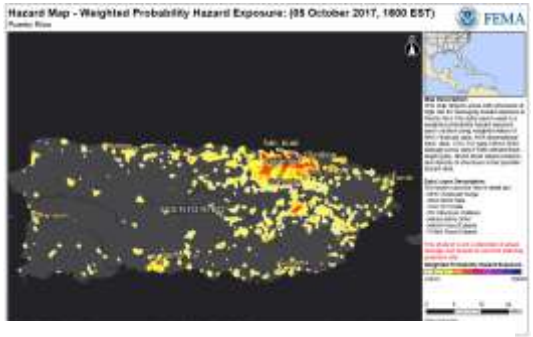
GPM and constellation satellites map Maria, data for NOAA/NHC and NRL

Flood mapping by the NASA team using ESA and Charter SAR and optical assets



Multiple flood-mapped scenes from NASA and commercial partners combined by FEMA to assess flood extent

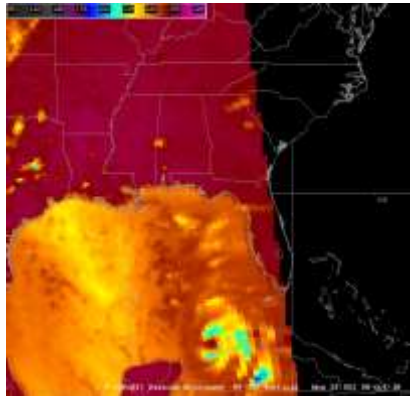
NASA Black Marble by National Guard teams for daily situational awareness.



NASA team damage proxy and flood information synthesized with other FEMA data to map impacts

Response and Engagement Timeline: Hurricane Michael

Team coordination began prior to 10/10 and continued daily throughout the event
Partners/Stakeholders engaged prior to and throughout storm's impact: FEMA, NGB, NOAA, USFS, USGS, US Army Geospatial Center, Department of Interior



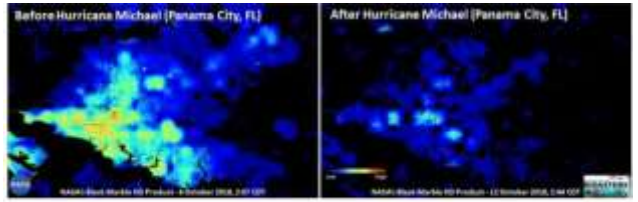
Monitoring the Storm: GPM data provided to support operational forecasting

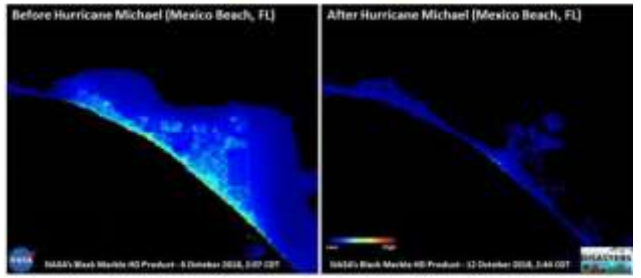
Damage Mapping: Damage proxy maps capture structure damage on immediate coastline

Flood Mapping: Identifying coastal and inland flooding from SAR imagery

NASA Black Marble HD:

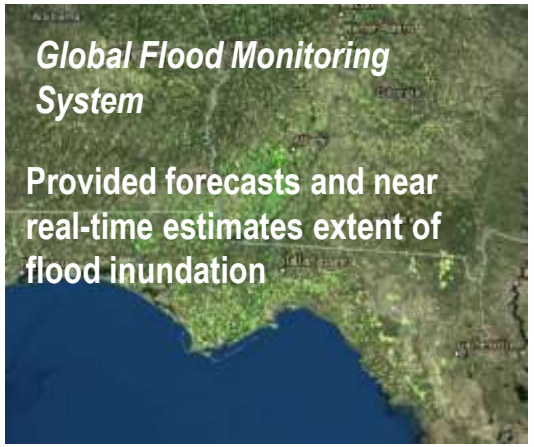
Black Marble HD: Captures lights missing in Florida's Energy Sector





10/8 — 10/9 — 10/10 — 10/11 — 10/12 — 10/16

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



Mapping Floods as Skies Clear:

MODIS & Landsat-derived flood maps in affected regions