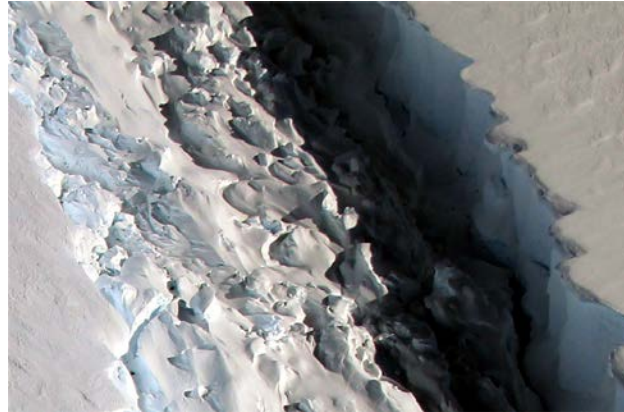
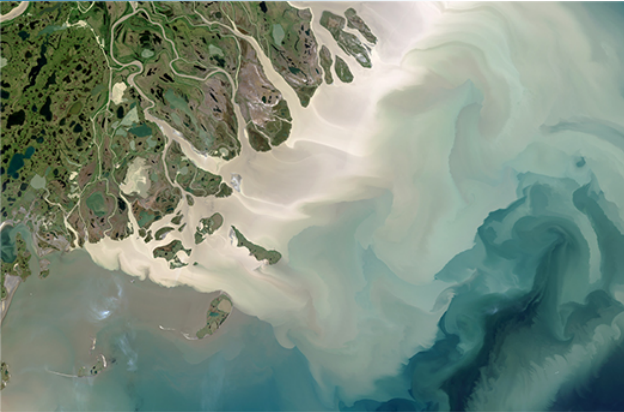




SCIENCE



AGU Fall Meeting 2018: NH13E-07

NASA Earth Science Activities Supporting Analysis and Response to the 2018 Hurricane Season

Andrew Molthan¹, Jordan Bell², and NASA Disasters Team
NASA Marshall Space Flight Center / Earth Science Branch¹
University of Alabama Huntsville / Earth System Science Center²

andrew.molthan@nasa.gov

jordan.r.bell@nasa.gov

December 10, 2018

Contributions from NASA Earth Science Elements

- Applied Sciences
 - Earth Science Disasters Program brought together NASA and sponsored investigators to support analysis of pre-landfall and recovery efforts.
 - Brings forward *NASA's Earth Science Disaster Response Team*, which includes multi-Center and institutional efforts to map damage and flooding – for Florence, in-person support at FEMA HQ to better understand their immediate and longer-term remote sensing needs.
- Research and Analysis (R&A)
 - Ongoing research regarding tropical cyclones, intensification, modeling, and use of NASA tools to map cyclone impacts, and sharing of data with the weather community via SPoRT Project
- Satellite and Airborne Science
 - With R&A and Applied, deployed G-III aircraft and UAVSAR instrument to the Carolinas to support immediate flood mapping, response activities, and collect data for longer-term science
- Earth Science Technology Office (ESTO)
 - Developed UAVSAR instrument, supports investment in NASA remote sensing and data systems technologies to support rapid acquisitions and sharing of information

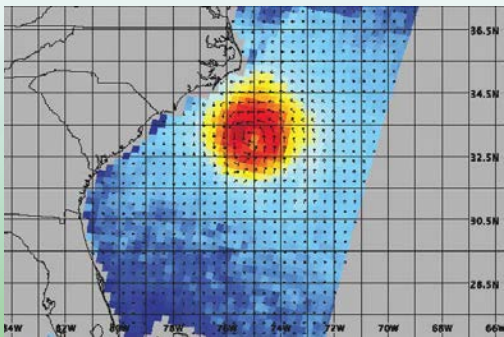
Contributions from NASA Centers and Partners

Team Membership	Name	Affiliation
Event Coordination	Jordan Bell Michael Goodman	University of Alabama Huntsville / NASA Marshall Space Flight Center NASA Marshall Space Flight Center
HQ Coordination	David Green, Gerald Bawden Jessica Seepersad, Carver Struve	NASA Headquarters a.i. solutions / NASA Headquarters
FEMA Liaison	Andrew Molthan	NASA Marshall Space Flight Center
UAVSAR Team	Yunling Lou, Naiara Pinto, Bruce Chapman Randy Albertson, John McGrath	Jet Propulsion Lab / CalTech Armstrong Flight Research Center / Airborne Science Program
SAR Tiger Team	Batu Osmanoglu, Nathan Thomas Sang-Ho Yun	NASA Goddard Space Flight Center ARIA / Jet Propulsion Lab / CalTech
Remote Sensing	Tian Yao	NASA LANCE Team / Goddard Space Flight Center
Landslides	Dalia Kirschbaum Robert Emberson	NASA Goddard Space Flight Center
Nighttime Lights	Miguel Román Ranjay Shrestha Lori Schultz	NASA Goddard Space Flight Center University of Alabama Huntsville / NASA Marshall
Int'l Space Station	Will Stefanov	NASA Johnson Space Center
GIS Team	Garrett Layne, Jeremy Kirkendall David Borges	a.i. solutions / NASA Headquarters Booz Allen Hamilton / NASA Langley Research Center
Communications	MaryAnn Jackson Jacob Reed	NASA Langley Research Center NASA Goddard Space Flight Center

NASA Mission Insights: Structure and Evolution

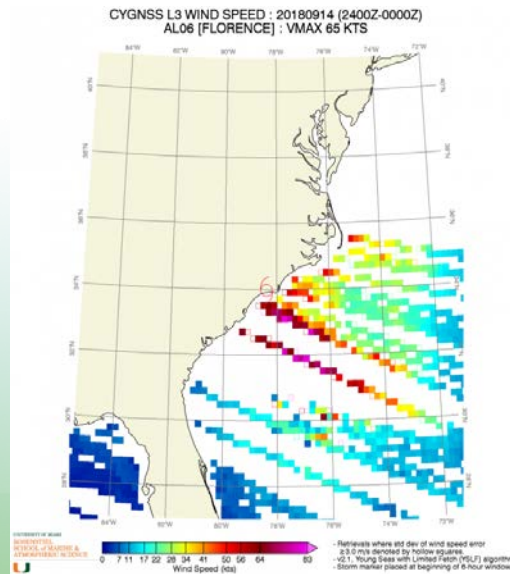
Ocean Surface Winds from SMAP

- SMAP observations are being used to estimate cyclone wind speeds, helpful for diagnosing and documenting the intensity and extent of impacts



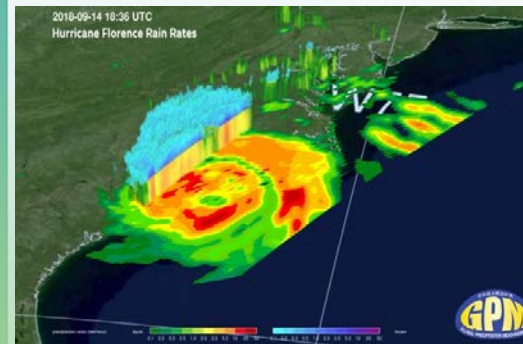
CYGNSS Wind Speed Measurement

- CYGNSS wind speeds capture higher spatial and temporal details of cyclone intensity



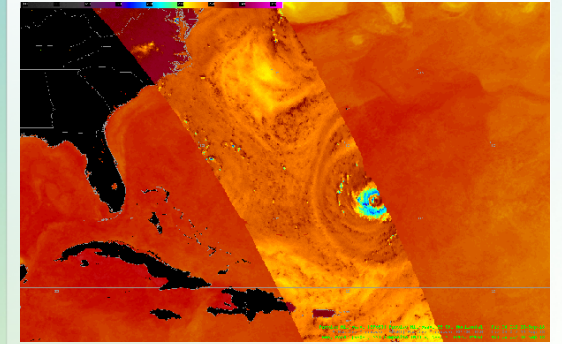
Monitoring Precipitation with GPM

- GPM Core and supported constellation provide routine mapping of torrential rains and storm structure, particularly valuable in offshore and radar-sparse locations



Supporting Operational Weather Forecasting

- Imagery from GPM, including views of storm structure and rainfall, provided along with other NASA mission data to the weather community through the SPoRT Center



NASA Mission Insights: Land Surface and Hydrology

Imaging the Earth to Capture Flooding

- Routine imaging by Landsat 8 and comparisons to historical record provide visual confirmation of flood extent and potential impacts



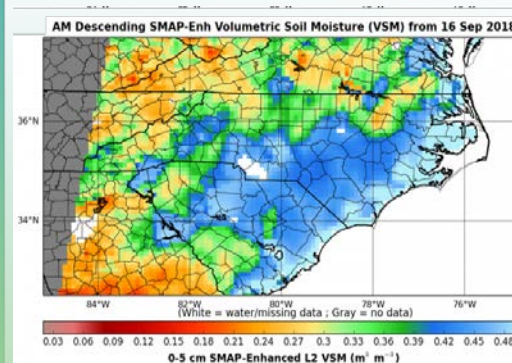
Coastal Impacts from Flood and Runoff

- Imaging captures sediment plumes and coastal pollution from inland runoff



Mapping Soil Moisture and Flood Risk

- Observations from the SMAP instrument capture wet soils, increased runoff, and longer-term impacts to agriculture and flood risk in the Carolinas



Soil Moisture Modeling and Climatology

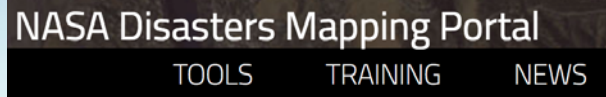
- Inclusion of SMAP, rainfall, and other information helps real-time predictions for understanding flood risk and improving streamflow models



Response and Engagement Timeline: Hurricane Florence



Integrated Sharing of Data via Esri Services



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

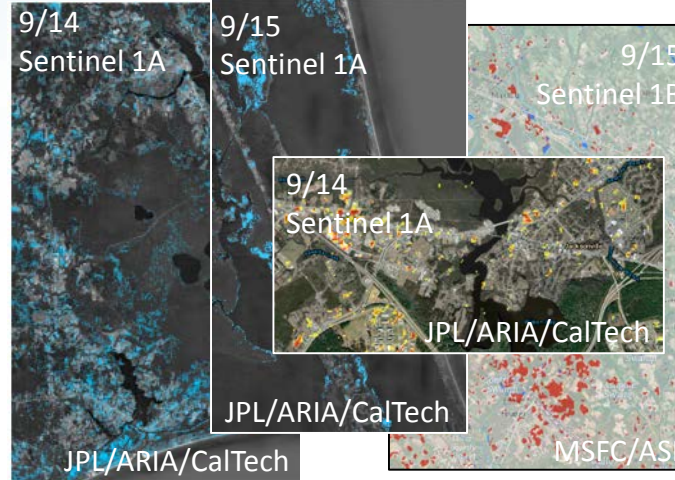


Forecasts for Florence identify likely, significant impacts to the southeastern U.S., and NASA team activates for coordination calls, product generation, and end-user engagement

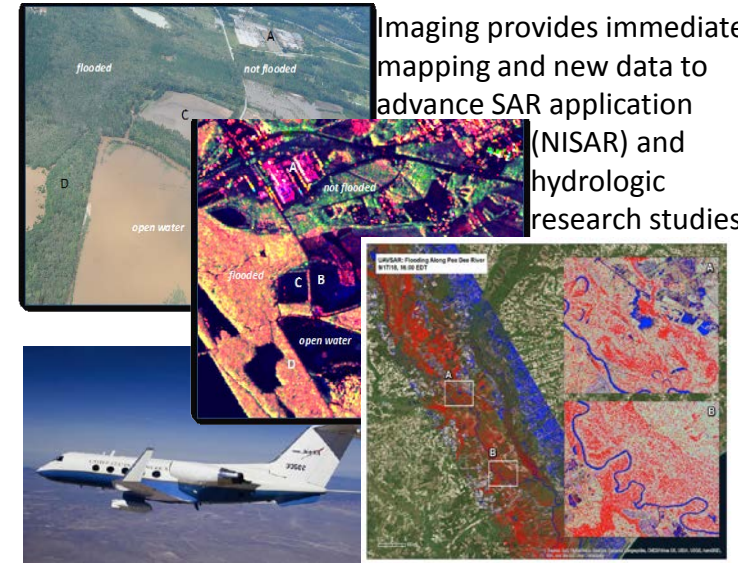


Photos from the ISS demonstrate the storm's intimidating size and intensity, capturing the attention of the public and media

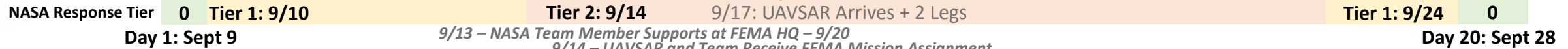
Flood Mapping: Team members generate flood and damage proxy maps via ESA and International Charter contributions to SAR imaging



UAVSAR Flights Support Research and Response Efforts



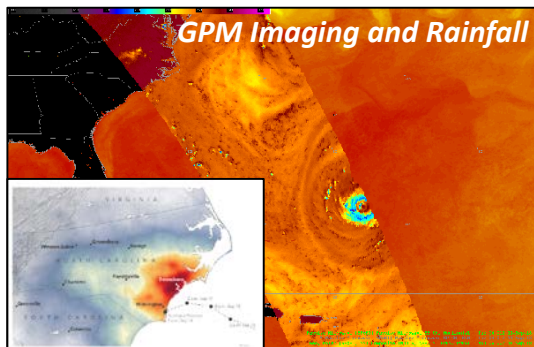
Imaging provides immediate mapping and new data to advance SAR application (NISAR) and hydrologic research studies



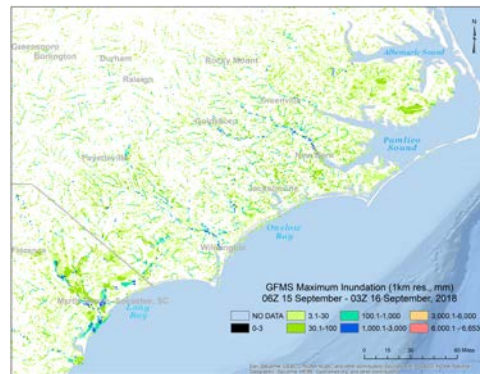
9/13 – NASA Team Member Supports at FEMA HQ – 9/20
 9/14 – UAVSAR and Team Receive FEMA Mission Assignment
 9/17 – NASA UAVSAR Flights to Support Science and Response – 9/24

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

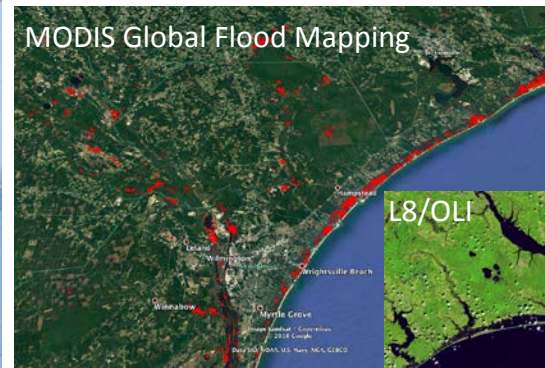
Pre-Existing Partners
 • FEMA, USFS, NOAA/NWS and NWC, USGS, National Guard,
 • Research/Academia



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

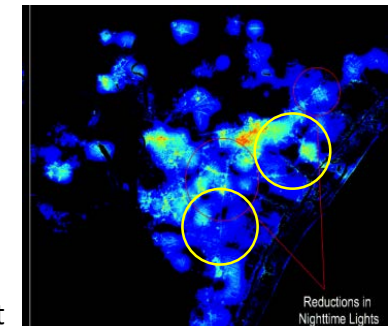


Global Flood Monitoring System estimates extent of inundation



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

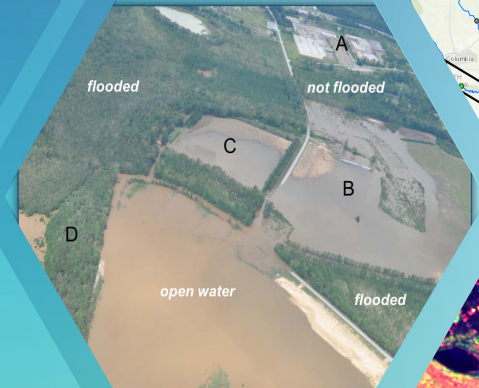
UAVSAR Mission Assignment



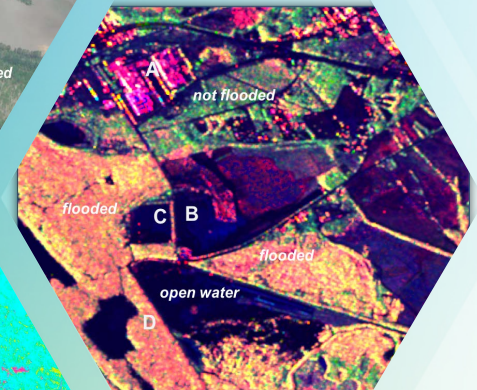
Assigned: 9/14



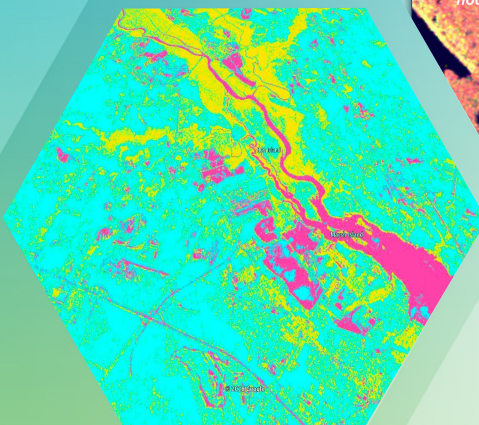
Daily Coordination



Observed Flooding



UAVSAR Signatures



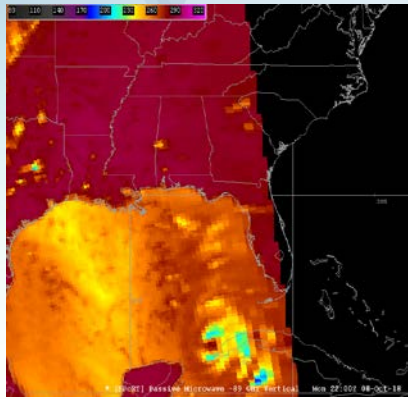
Mapped Information

- 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 2021

Response and Engagement Timeline: Hurricane Michael



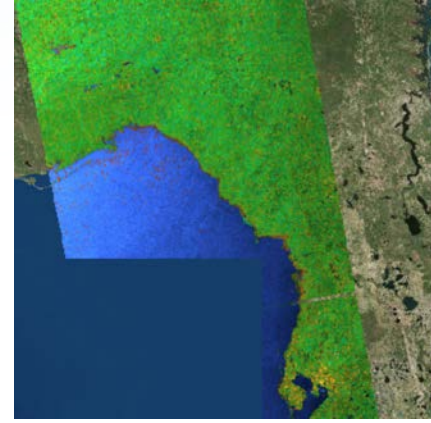
Team coordination began prior to 10/10 and continued daily throughout the event
Partners/Stakeholders engaged prior to and throughout storm's impact:
 FEMA, NGB, NOAA, USFS, USGS, US Army Geospatial Center, Department of Interior



Monitoring the Storm:
 GPM data provided to support operational forecasting

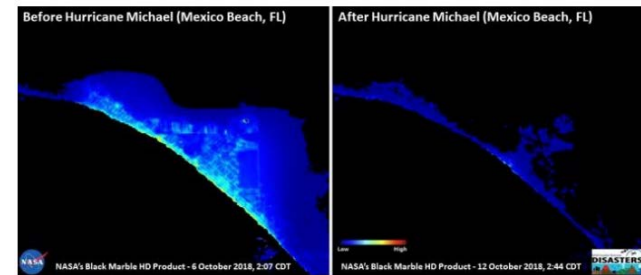
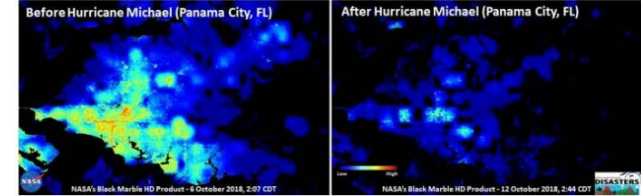


Damage Mapping: Damage proxy maps capture structure damage on immediate coastline



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



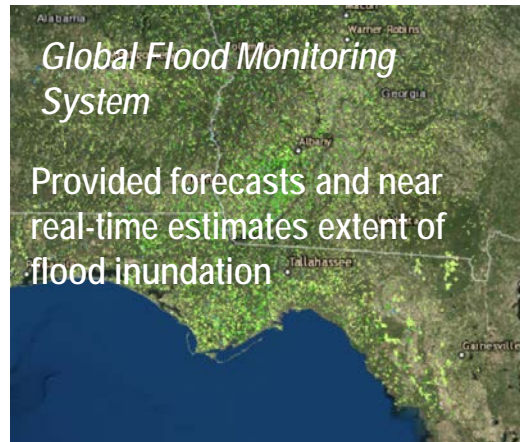
10/8



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

10/9

10/10



Global Flood Monitoring System

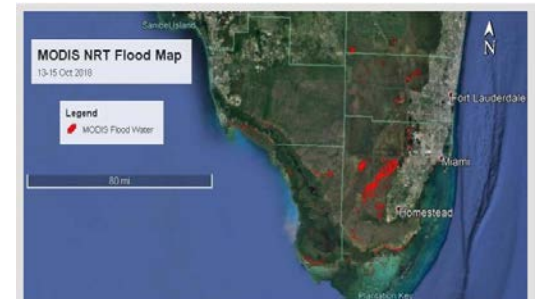
Provided forecasts and near real-time estimates extent of flood inundation

10/11

10/12

10/16

Mapping Floods as Skies Clear:
 MODIS & Landsat-derived flood maps in affected regions



Results, Experiences, and Future Efforts

- Based upon recent experiences with Hurricane Florence:
 - Coordination with other federal agencies and partners (FEMA, NOAA/NWS, USGS, National Guard, USFS, and others) is critical to understanding data needs, response and future research or applications questions, and to identify future opportunities
 - Participation at FEMA helped NASA to understand the types of questions being asked, methods for best use of data, limitations of various platforms, and paths forward on research and applications
 - Routine coordination with other partners on calls are similarly helpful. To sustain engagement and improve for future events, participate in after-action reviews and work with partners on product, training, and delivery needs
 - Mission assignment of UAVSAR helps NASA to practice and refine internal policies and procedures for rapid airborne deployment. Partnerships refined with scientists to produce reduced latency analyses, along with follow-on products of greater accuracy and detail
 - For example, collection of SAR imagery from ESA, International Charter, and other partners, delivery of output mapping and UAVSAR information to HDDS and other portals, training, etc.



Questions?