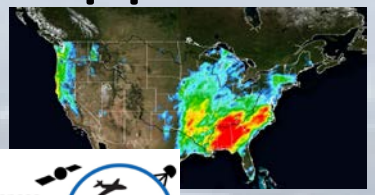
NASA Tier 1 Response to Record Flooding
Mapping a Disaster from Illinois to Mississippi
December 29, 2015 – January 15, 2016



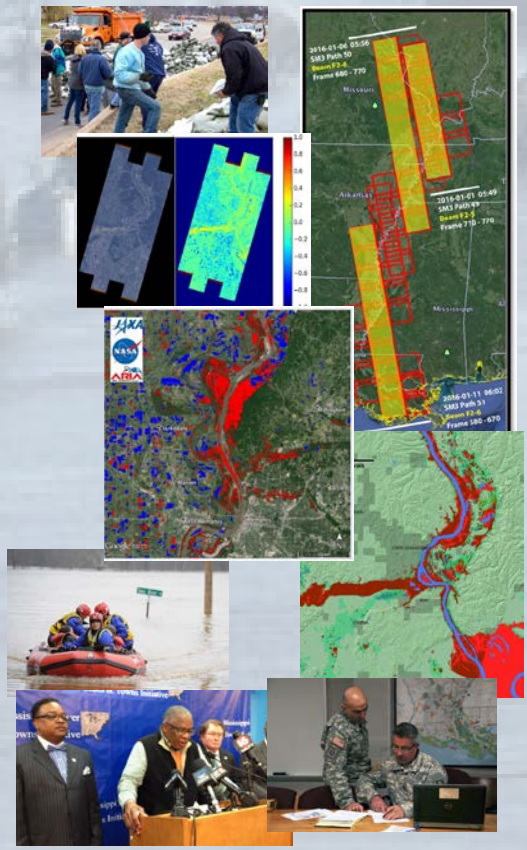
NASA is providing unique, timely and effective support including data, products and strategic guidance daily.

- Consolidated flood and water-index maps
- GIS-capable web-mapping, visualization and decision tools
- Inundation and Damage proxy maps/assessments
- Imagery and interpretive support

NASA Disaster Program joined FEMA's HQ Geospatial Unit in an Interagency SAR Tiger Team with NGA, NOAA, USGS, and USDA based on lessons from SC floods

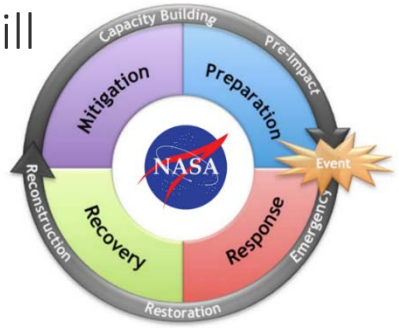
- Prioritized, shared, ingested and processed SAR and optical data over areas of interest and disseminated products to stakeholders

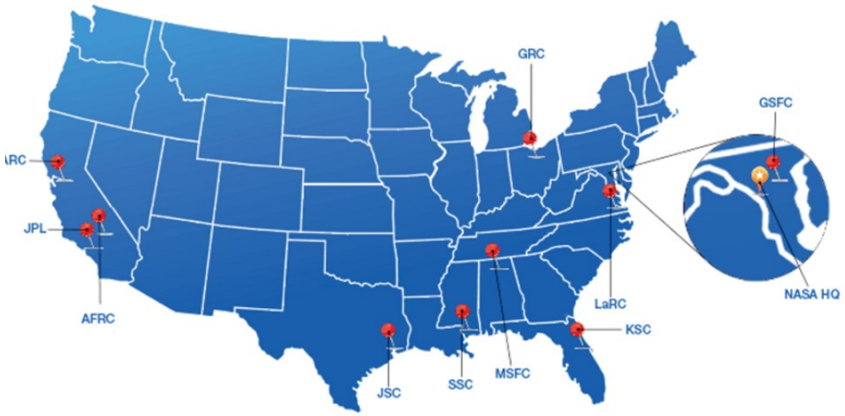
Regional and local incident responders, NWS Weather Forecast Offices and Southern Regional Operations Center, Storm Prediction Center (Disaster Assessment Toolkit), National Water Center, USGS HQ and EROS Data Center (*Disaster Charter*), NGA Operations, State and local government, military officials, resource agencies, private sector, media and public.



Advancing NASA's Disaster Response

- **Disaster application science** is focused on the two-way flow of data and information between hazard understanding and the knowledge required for disaster response and recovery.
- **Coordination and collaboration** with stakeholders/end users will significantly enhance our ability to provide relevant products for direct situational awareness and use
- **NASA's EO data and products** provide relevant, timely information for response and recovery efforts and can be improved with sustained partnerships throughout the disaster lifecycle





Rapid Assessment and Tiers of Disaster Response

Assessment: 30-50 events per year
Tier 1: 10-30 events per year
Tier 2: 3-10 events per year
Tier 3: 0-3 events per year

Assessment

Rapid Hazard Assessment Expected

- Centers and program experts to contribute within scope of daily activity
- Guidance to elevate to Tier response, direct to research or no action
- Days

E.g.: media report

Tier 1

Response and Recovery Short Term and Best Effort

- Centers and programs respond as available with only minor impact to existing/on-going activities
- Detailed assessment and products scaled to modest response
- Weeks to Month(s)

E.g..: Napa Earthquake (2014), Chile Earthquake (2015), Oklahoma tornadoes, yearly floods

Tier 2

Significant Contributions Over Extended Period

- Contributions are considerable given continual assessment of size and scale of impact
- Personnel relevant to disaster type (s) expected, tasked, and assigned to support
- Data and products adapted into recovery
- Weeks to Month(s)

E.g.: Nepal Earthquake (2015), Deep Horizon (2010), Eyjafjallajökull Eruption (2015)

Tier 3

Disaster is of major national importance

- All relevant personnel expected to review activities for level of support to the disaster and/or be on-call
- Assets and personnel may specifically assigned and tasked for lengthy time period (Months into recovery).

E.g.: Hurricane Katrina (2005), September 11, 2001 attacks

International and Domestic Coordination Sharing relevant data

- Group on Earth Observations
- Committee of Earth Observing Satellites
- International Disaster Charter

Domestic (*a selection*)

FEMA

USGS science for a changing world

U.S. Army Corps of Engineers®

NASA's Earth Observing Fleet

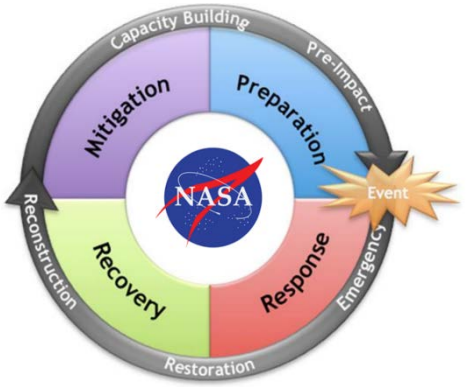
- Atmosphere
- Land
- Oceans
- Cryosphere

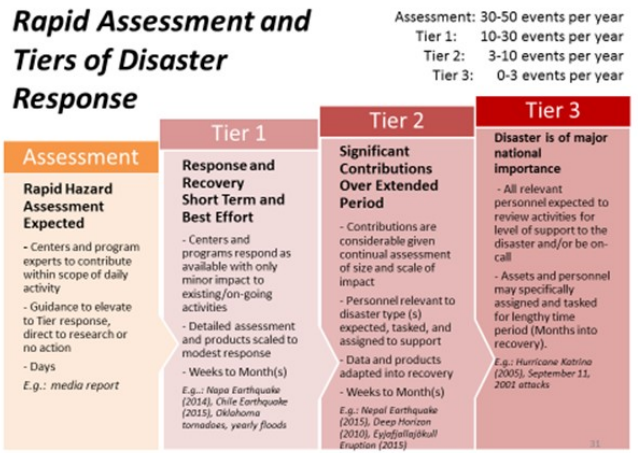
NASA Activation: Rapid Assessment and Tier 1 - Support and Cooperation

Disaster Program Liaison Activities & Operations Support

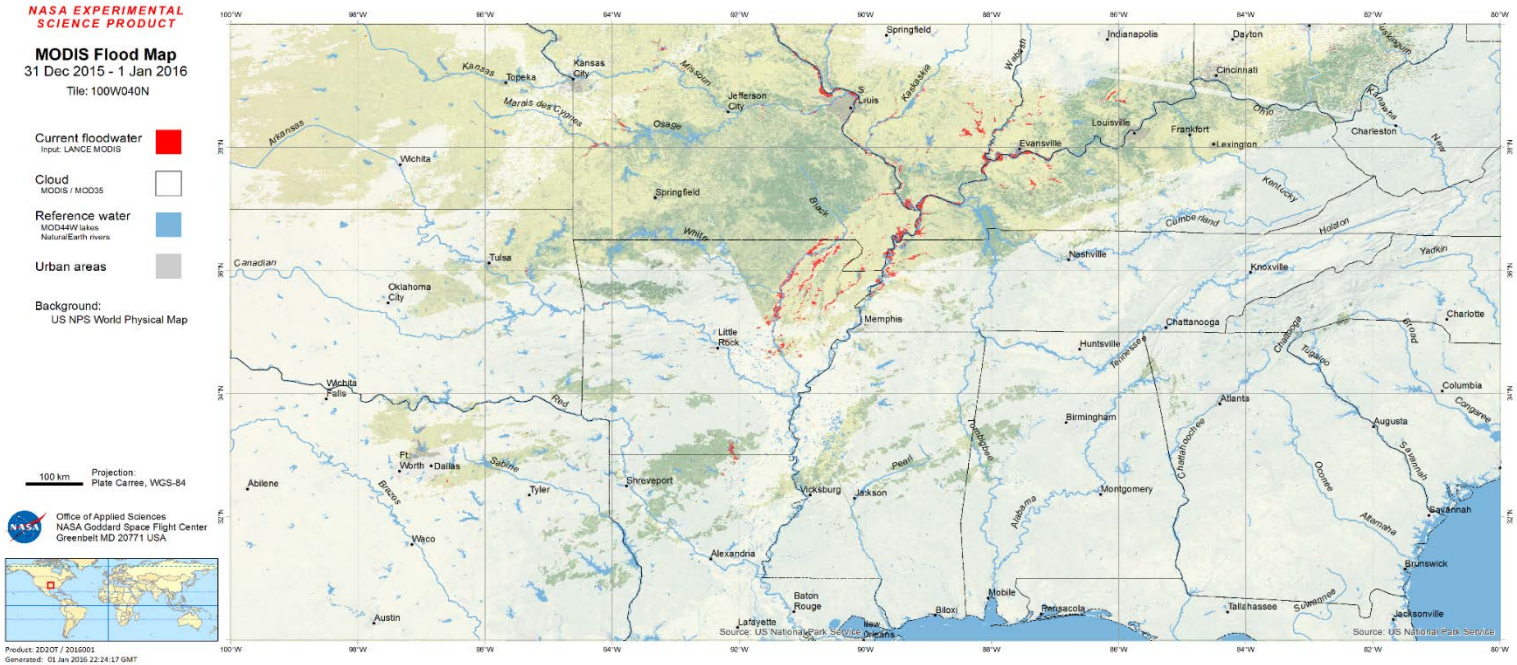
- Routine collaboration throughout disaster cycle with FEMA SAR Tiger Team, USDA, NGA, NOAA and USGS
  - On-call support and interagency coordination
  - Assure data is ingested, available, and understood
  - Enable automated systems for processing and product creation
  - Work across NASA Centers and PI's to conduct geospatial modeling; furnish decision support systems
  - Operate and maintain web information pages
- Coordination support to the International Charter Space & Major Disasters*
  - Radar: COSMO SkyMed, ALOS-2, RADARSAT-2, RiSAT-1, TERRA SAR-X, Sentinel 1A …
  - Moderate Res Optical: EO-1 ALI, ASTER, MODIS, Landsat 7, SPOT, ISS,
  - High Res Optical: Worldview…
  - Aerial Imagery: Civil Air Patrol, NOAA,
- Engagement with JAXA to obtain relevant ALOS-2 data
- Coordinated across CEOS Disaster Working Group

NASA Applied Sciences DISASTERS





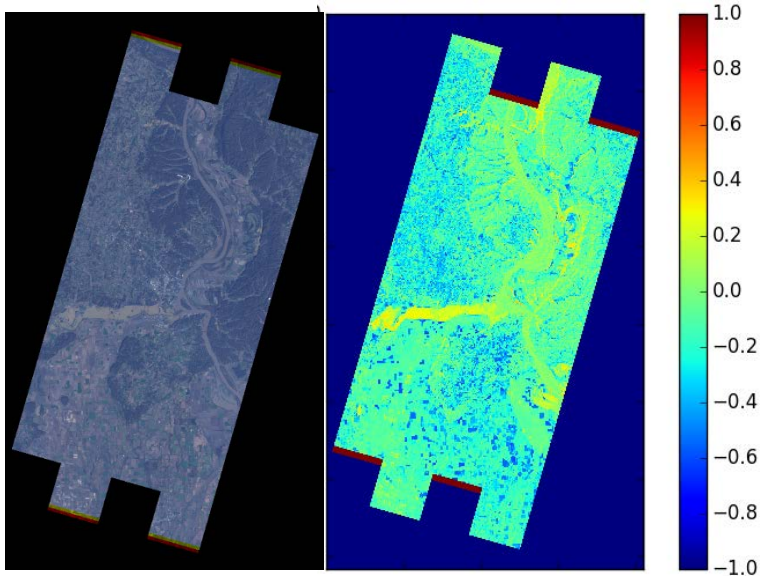
Product Examples

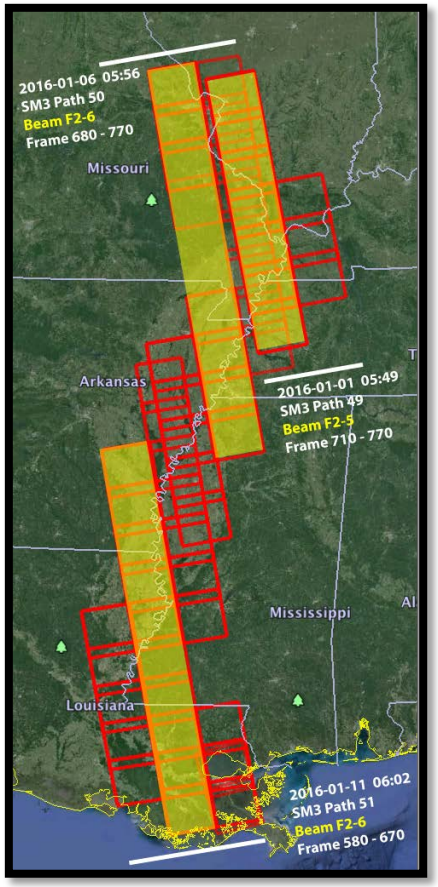


Near Real-Time MODIS Global Flood Mapping depiction of flood areas (red pixels) depicting flooding in the central and southeastern United States. GeoTIFF and other versions of this product were provided to FEMA along with guidance on use and interpretation.

Product Examples: Normalized Water Index and Areas of Interest

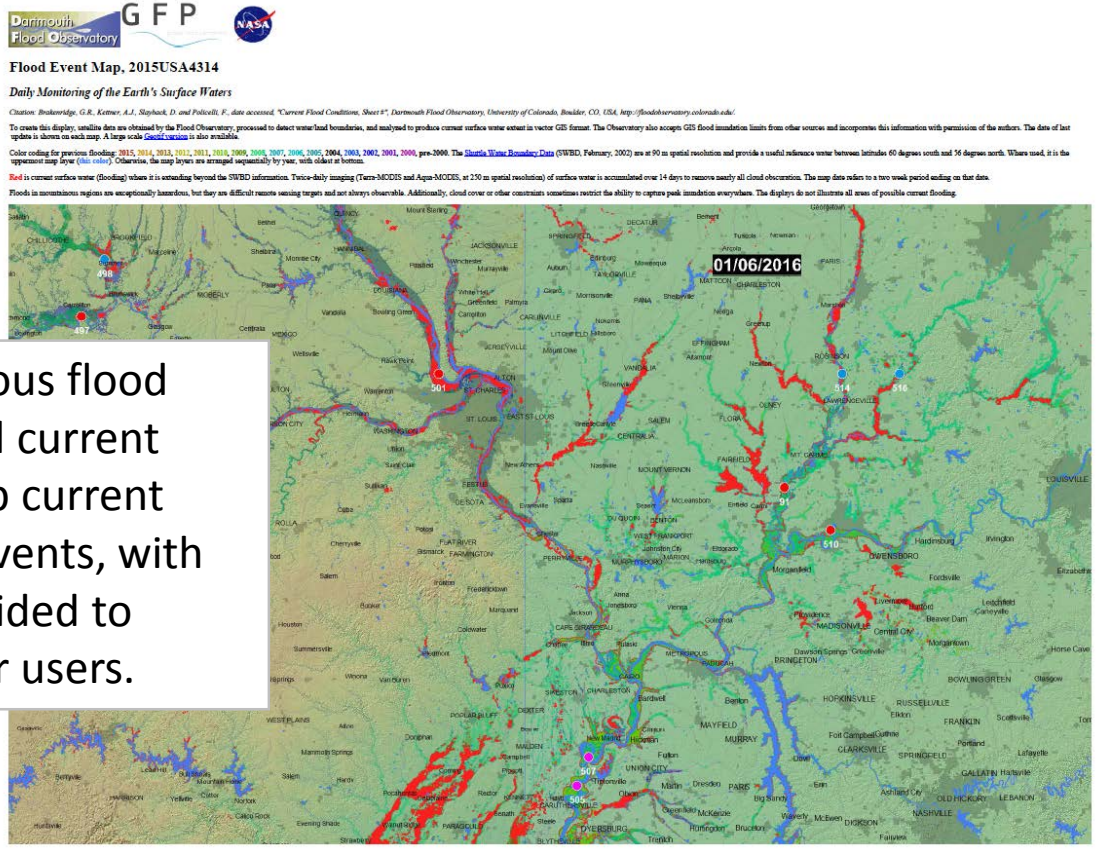
FEMA HQ Geospatial Unit: " As I mentioned already, the NDWI product you sent on day 1 conveyed a world of possibilities for us that we have never tapped. "





(left) Examples of EO-1 true color imagery for Cape Girardeau, MO on Jan 1, 2016, and derived normalized difference water index, provided to FEMA and other partners for use and assessment. (right) Strategic guidance on collection of ALOS-2 provided by SAR team to coincide with FEMA areas of interest at peak flooding.

Product Example: Changing Flood Zones



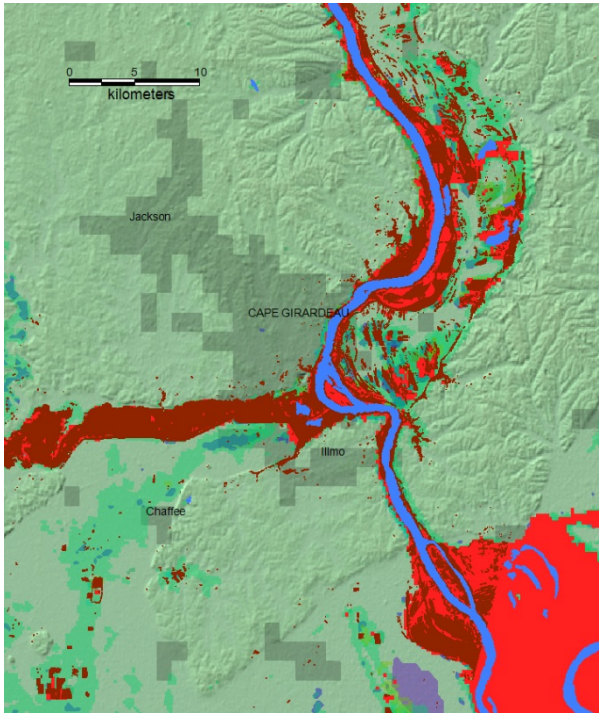
Mapping of previous flood zones (colors) and current flood (red) to map current versus previous events, with product also provided to FEMA and Charter users.

FEMA HQ Geospatial Unit *"As I see from the list of new acquisitions by the International Charter or NGA/USGS-HDDS, I see WorldView 3 and other medium to high resolution visible systems are collecting valuable data. Despite our partnerships and contracts, we are challenged to exploit it all and synch it with the flood extents being provided by SAR exploitation and products*

Product Example: Using Multiple Sensors to Answer Questions

NASA imagery used alongside commercial and international imagers to aid in comparison of SAR products, or merged optical/SAR approaches.

Collection of EO-1 data over cloud-free Cape Girardeau provides an opportunity to help validate coarser resolution MODIS products. Here, EO-1 (dark red) is superimposed upon MODIS (red). MODIS misses some of the smaller areas mapped by EO-1 but provides greater spatial coverage.



Comparison, EO-1 superimposed over MODIS.

MODIS misses small areas of flooding mapped by EO-1, but has spatial coverage over the entire region.

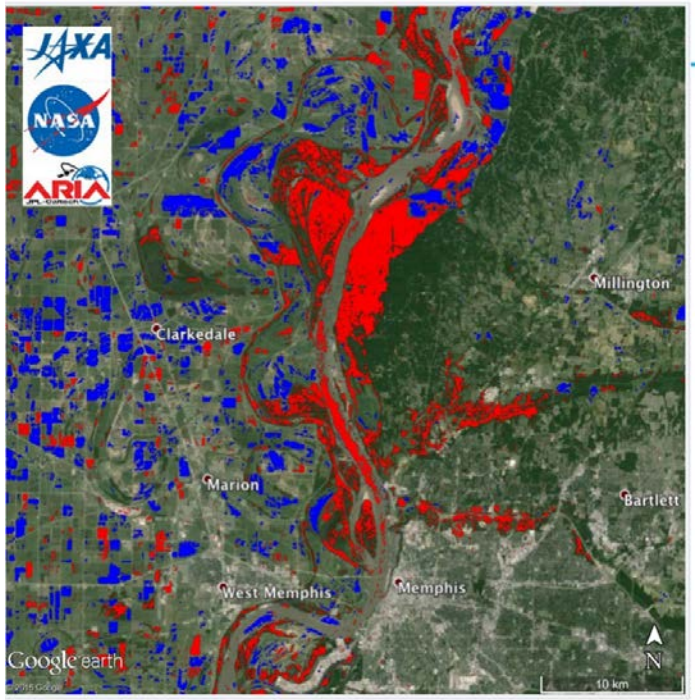
FEMA HQ Geospatial Unit: "FEMA may be able to adopt this automated approach and with our guidance incorporate some derived multi-spectral products in the near term, and also serve as a platform for other products developed in collaboration with other NASA partners. This could improve their access to and usage of the higher-resolution commercial data".

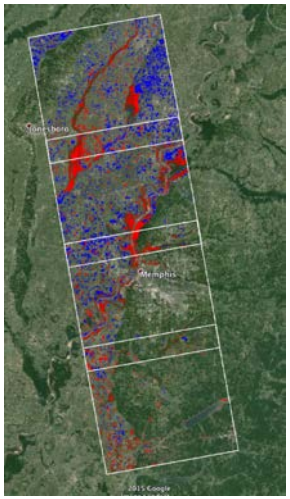
Product Example: Flood Extent Map

Flood extent map used as guidance and provided to FEMA and other incident response agencies to identify flooded areas.

Mapping may be less reliable over urban areas.

Original data ALOS-2 PALSAR-2 Product - ©JAXA (2016).





Flood Proxy Map on Google Earth

https://aria.jpl.nasa.gov/case_studies

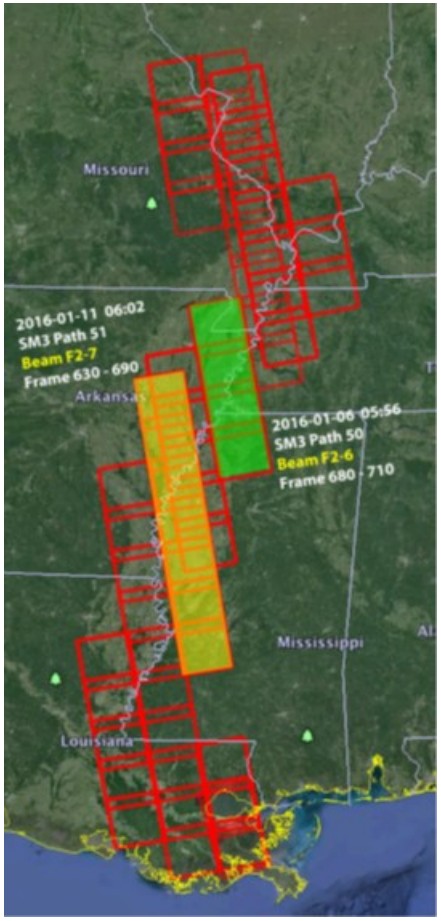
Targeting Flood Evolution

ALOS-2
Passes on January 1, 6 and 11th 2016, targeting boxes for ALOS-2 stripmap mode. Each stripmap has 3 potential collection beams for an overpass. 1 beam can be requested.

- Direct request from NASA to JAXA
- Collection of stripmaps 1,2,3 and shaded in yellow in the image corresponding to 01-01, 01-06, 01-11 overpass dates.

Updates as of January 12th 2012

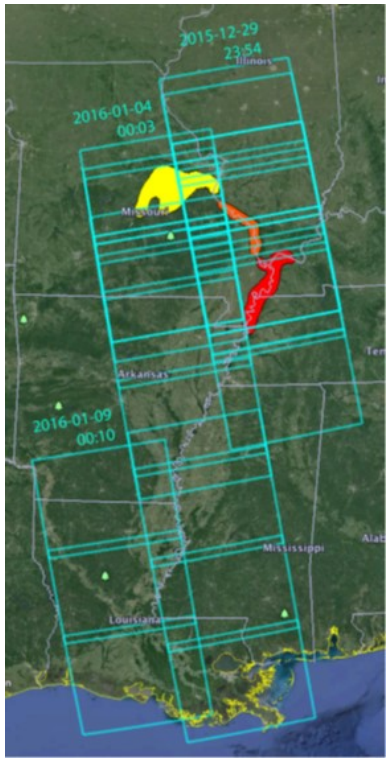
- The green strip (4 frames, including Memphis and Osceola) processed and flood extent map created
- JAXA acquired data over yellow strip (7 frames) and released through the International Charter.

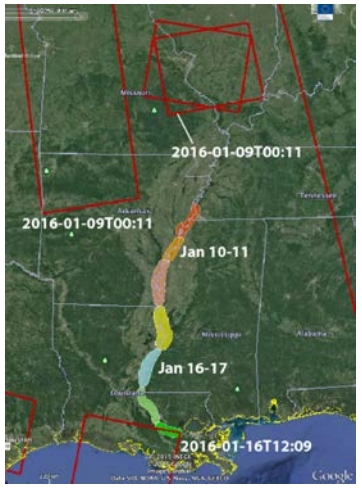


Sentinel-1A: Flood recovery assessment maps

January 9 track, which includes good portion of Louisiana including Baton Rouge, which crested January 18th and is slow to resolve, will be useful at this later stage of flooding.

A flood assessment map for a focused part of the frame was produced within 2 days.



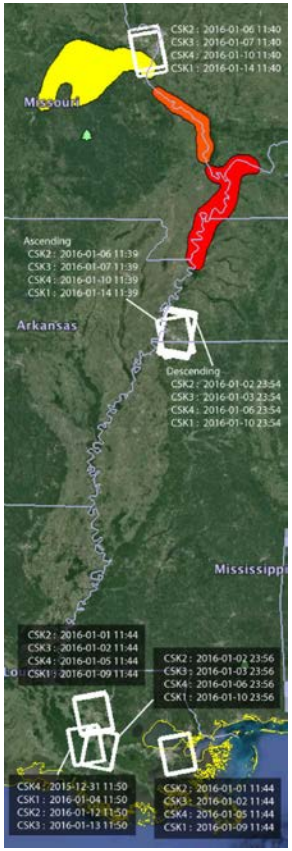


Single “slice” acquired on January 10, 2016 including St Louis. Plan to acquire further north along Relative Orbit 172
January 16th. No pre-event scenes over the strip to compare

COSMO SkyMed Flood Recovery Assessment Mapping near Urban Centers

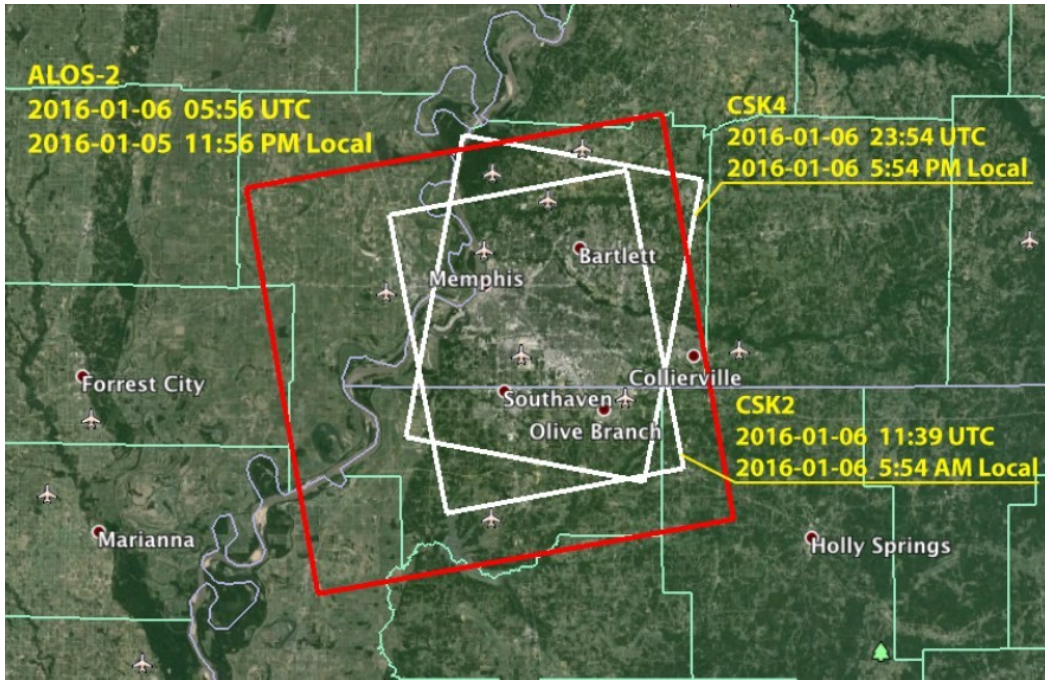
Passed on January 2 and 14th over St. Louis, Memphis, New Orleans

- ASI's basic observation scenario is to cover major cities in the world. Thus the smaller localized collection boxes.
- Request to ASI can come from NASA with FEMA priorities identified.
- Once data is acquired derived flood assessment map can be produced in ~1 day.



Product Example: Memphis flood and recovery mapping

ALOS-2, COSMO-SkyMed passes on January 6, 0 AM (A2), 6 AM (CSK), 6 PM (CSK)



NASA Disaster Response – Science for Disaster Risk Reduction and Resilience

Regional Support
Planning
Education
Training

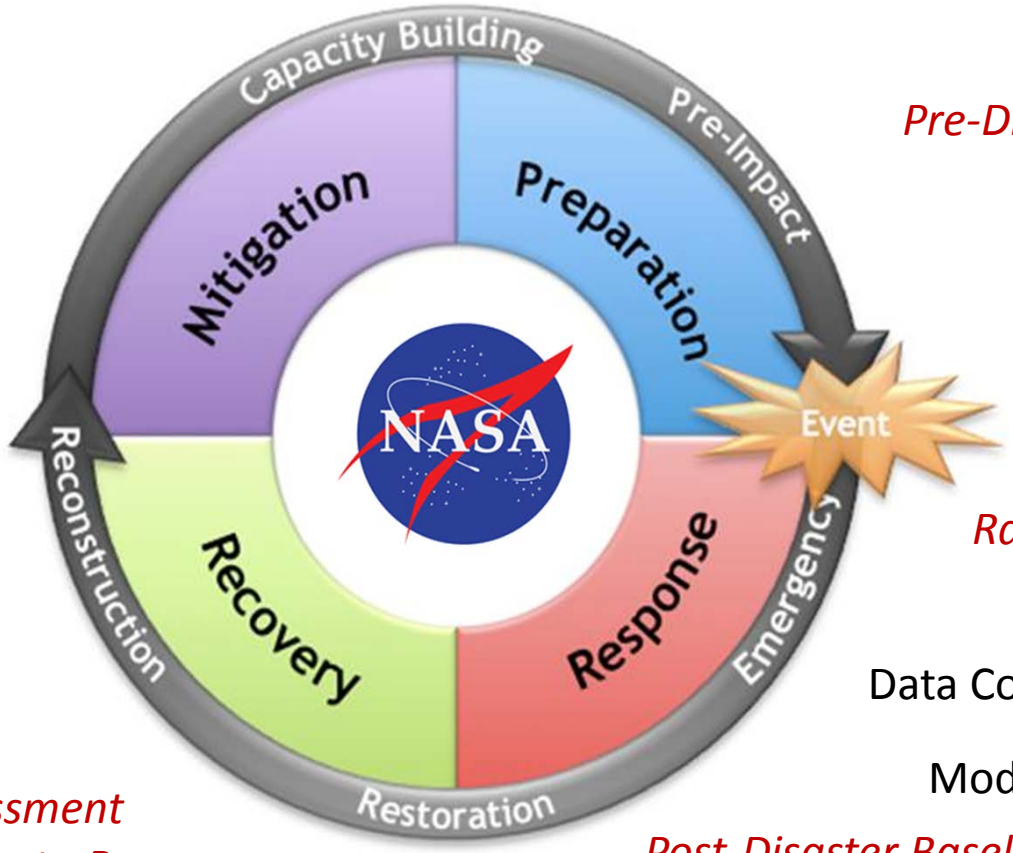
Monitoring

Natural Laboratories/
Observatories

Pre-Disaster Baseline Assessment

Prediction and Forecast

Detection



Monitoring

Recovery
Observatory

Rapid Assessment - Response

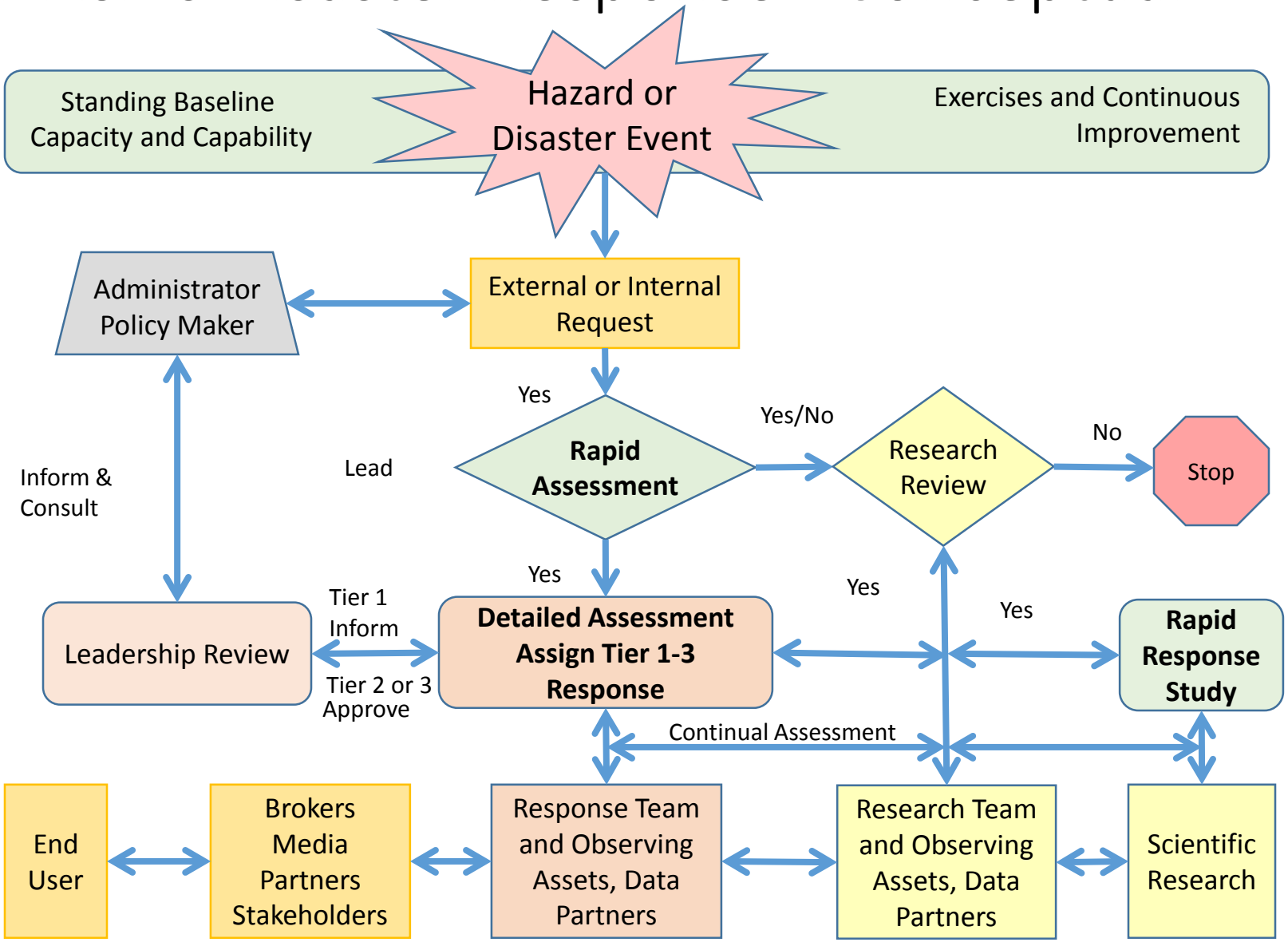
Data Collection & Input

Modeling, Mapping

Continual Assessment
Rapid Assessment - Recovery
Post Disaster Needs Assessment

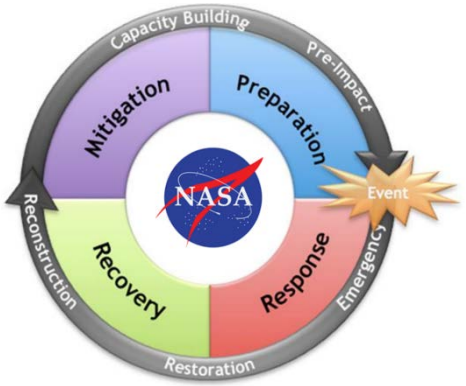
Post-Disaster Baseline Detailed Assessment

NASA's Disaster Response - Conceptual



Response Time Line

December 29: Evaluate Event / Entrance Criteria
-- Significant flooding ongoing/expected
-- Unique NASA imaging and products available
-- Potential customers in FEMA and NOAA
-- Research opportunity: understand and improve upon capabilities for remote sensing of inundation using SAR and/or optical techniques.



December 30: Tier 1 Response
-- Andrew Molthan / Dalia Kirschbaum to coordinate
-- Coordination call to discuss event and support
-- Identify opportunities for SAR, EO-1, ASTER
-- Assess Landsat 7/8 opportunities; GPM; MODIS products
-- Received guidance from FEMA on collection interests

December 31: Continued Response
-- Coordination call to discuss event and support
-- Identify opportunities for SAR, EO-1, ASTER
-- Assess Landsat 7/8 opportunities; GPM; MODIS products
-- NASA team participates in FEMA SAR Tiger Team calls to discuss coordination of SAR / optical collections and data needs

December 2015 January 2016

Mid Response Time Line

January 1: EO-1 Collection

-- Team selected Cape Girardeau, MO for targeting at crest of record flooding, and imaged.
-- True color and NDWI imagery provided to FEMA and other partners assessing flood extent.
-- NRT Global Flood Mapping from MODIS provided to FEMA as skies remained clear
-- Products were also shared to USDA remote sensing coordinator and distribution list (500+)
-- EO-1 imagery also used to help validate NRT Global Flood Mapping from MODIS (Jan. 8)

January 3: Continued Support

-- Monitoring of the evolution of the flood, targeting of imagery
-- Stand down of coordination calls and transition to virtual tag-ups via email

January 4-5: Participation in FEMA Tiger Team

-- Daily FEMA SAR Tiger Team calls with NASA coordinators and SAR expertise, including discussions with FEMA and contractors on SAR collection strategy and data sharing.

January 6: EO-1 and ASTER Collections

-- Team selection of EO-1 imagery near Osceola, AR captured the event at major flood stage, and may provide value when combined with SAR collection over the same area. ASTER targeting collected some views of flood waters near St. Louis. Shared with FEMA.

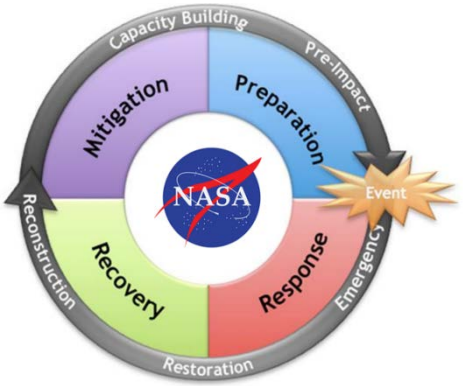
January 8: Continued Support

-- Participation by coordinators / SAR team with FEMA regarding upcoming Charter collections of multispectral and SAR imagery as flooding moves downstream.

Termination of Tier 1 Response Transition to Recovery Observatory Time Line

January 9-15: Ongoing Support

-- Continued participation in FEMA SAR Tiger Team calls, as needed.
-- Evaluating opportunities to generate flood mapping from collected SAR and optical imagery
-- Continued guidance on collection of SAR from Sentinel-1, other partners
-- Additional opportunities for EO-1 and ASTER collections pending cloud-free conditions
-- Flooding expected to continue downstream into portions of Arkansas, Tennessee, Louisiana



January 2016