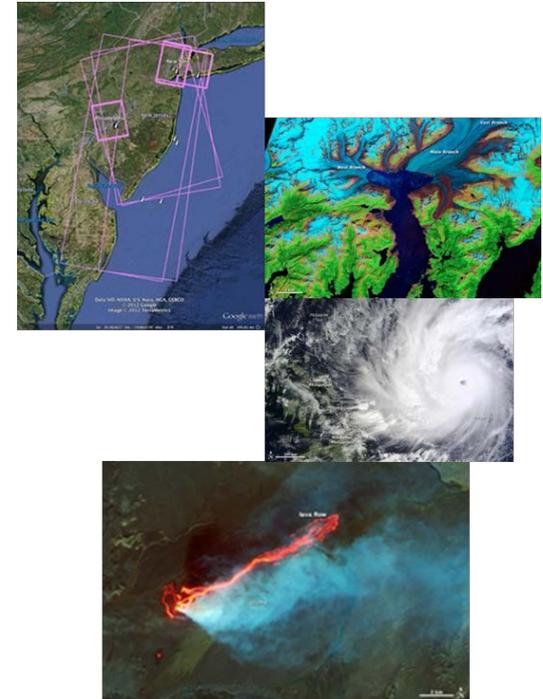
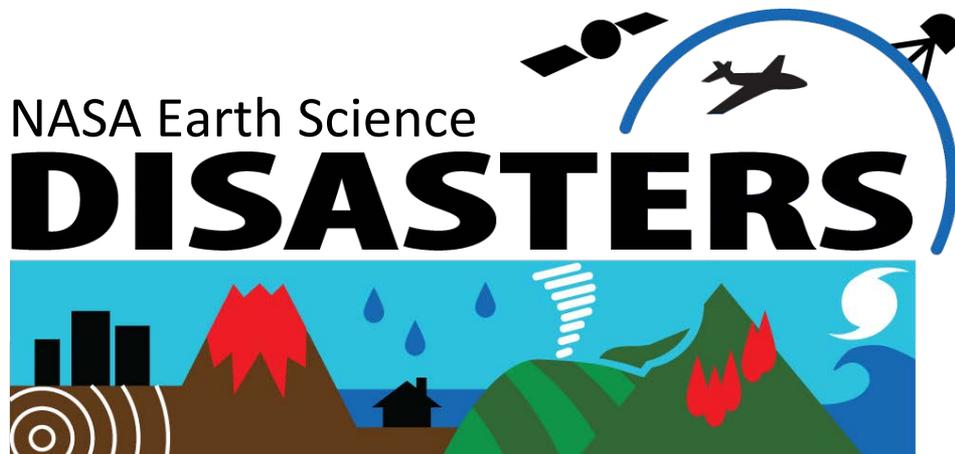


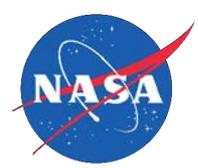


# NASA's Disaster Response Program and Role of Earth Application Science

**Dr David Green**

NASA Applied Sciences Program  
Earth Science Division  
David.S.Green@nasa.gov





# Conversation with Wildfire Program

- Coordination Team interested in Wildfire Program Roadmap and options for alignment with Ecosystem and Disaster Programs
- Engagement with Disaster Response Plan
  - Playbook for Wildfire Response and cascading hazards e.g. landslide and flood
  - Disaster Portal coordination
  - Rapid Response
  - Interagency Partnerships
  - Low-latency data and models/LANCE



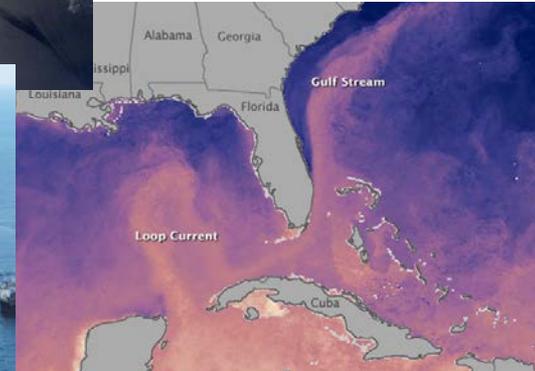
# NASA Providing a Unique Perspective for Disaster Response and Recovery



Atmosphere, Land, Oceans, Cryosphere



## Deepwater Horizon Oil Spill, 2010



Earthquakes



Volcanoes



Landslides



Floods



Fires



Land Subsidence

*Multi-hazard and Global*

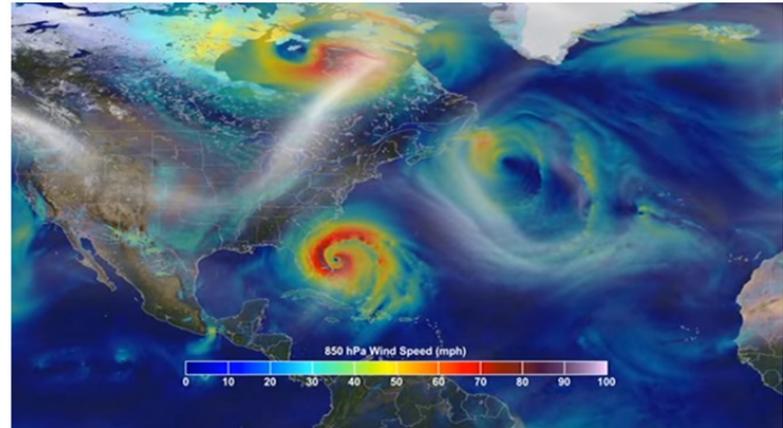


# Hurricane Sandy October 2012 NASA Supporting Operations

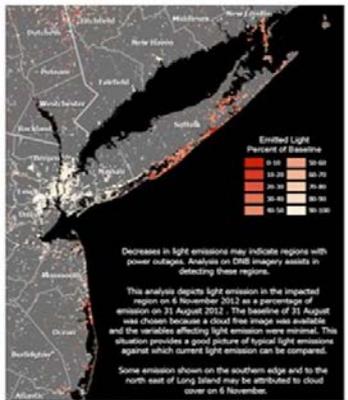
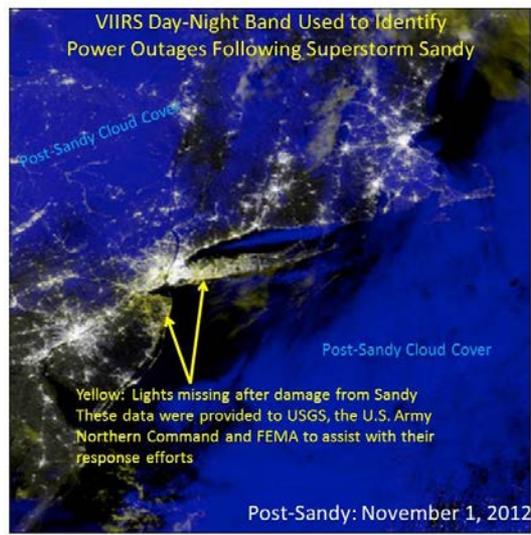


NASA collecting data; providing imagery and model results

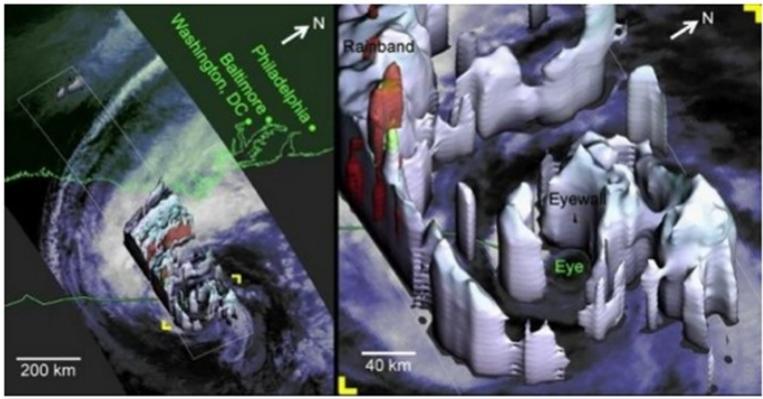
Providing situational awareness relevant to disrupted energy and transport, exposed ecosystems and infrastructure and areas of likely health and safety impact



NASA's Goddard Space Flight Center and NASA Center for Climate Simulation



SPoRT provided VIIRS data to the Joint Task Force Civil Support (JTF-CS) and the Department of Defense Northern Command (NORTHCOM). With SPoRT's support, analysts adapted the VIIRS data into their own product to help gauge power restoration in support of recovery efforts.



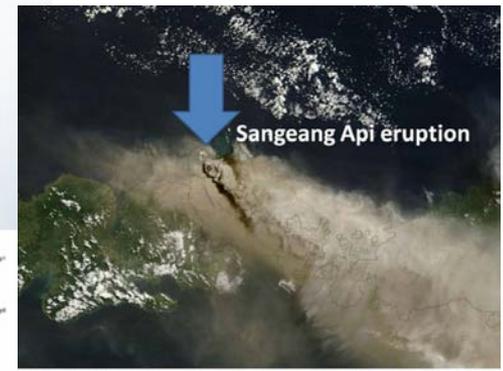
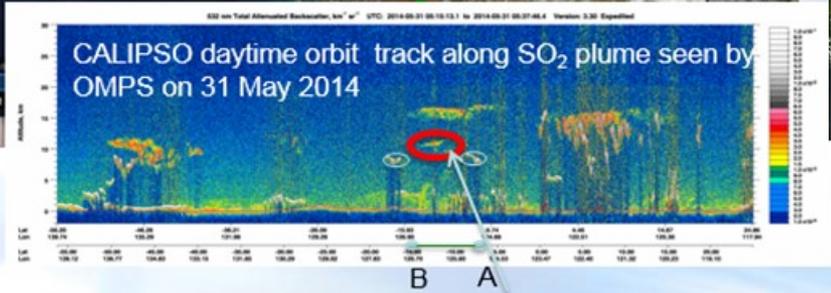
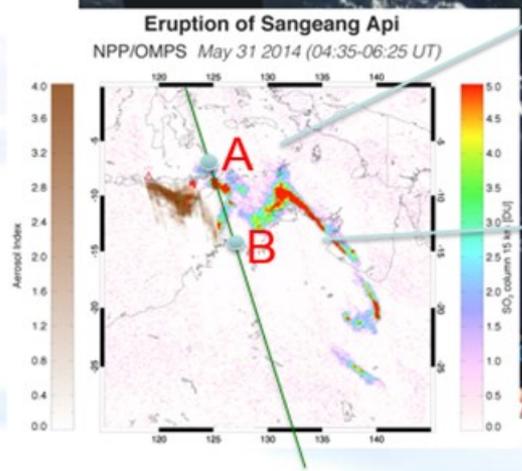
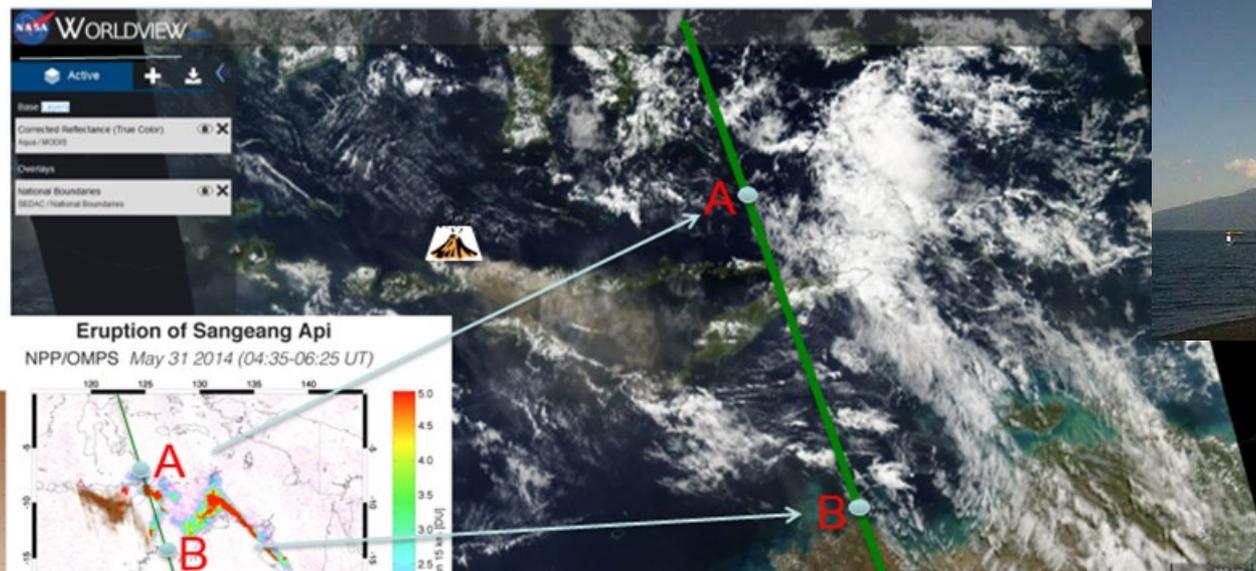
Hurricane Sandy as viewed by the TRMM Precipitation Radar at 2:20 EDT on Oct. 28, 2012.





# Sangeang Api volcanic cloud on May 31 2014

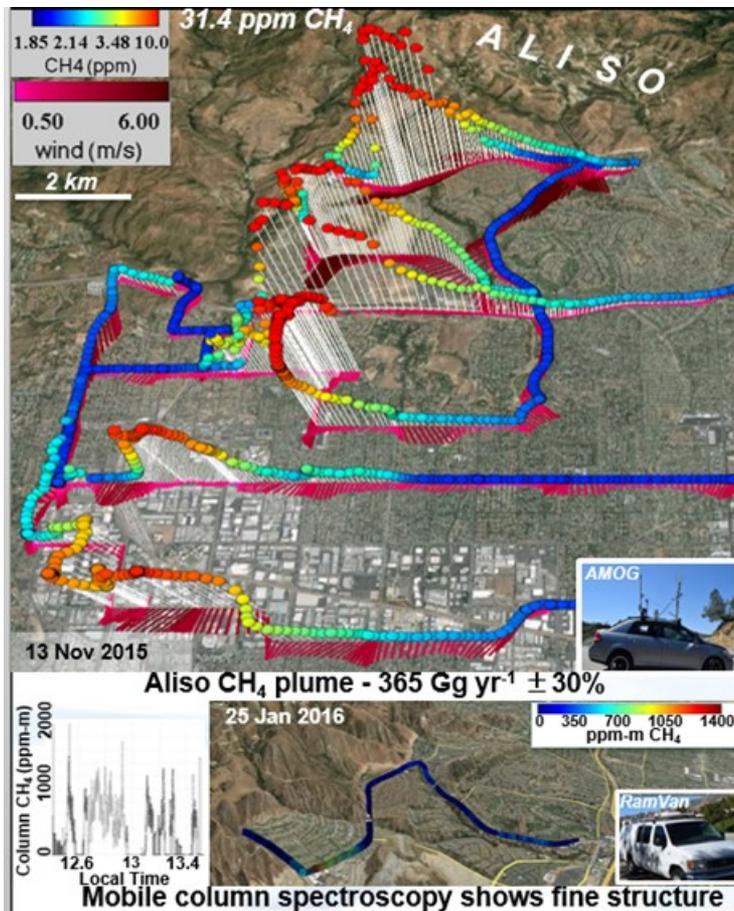
MODIS true color, SNPP OMPS SO<sub>2</sub> and CALIOP (11 km) observations



NASA Terra MODIS imagery of the Sangeang Api eruption in Indonesia.



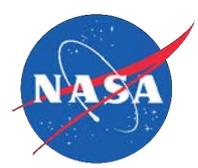
# Aliso Canyon Methane – January 2016 Rapid Response?



- Strong chemical release disasters are “atmospheric tracers” of urban transport.
- Topography controls strongly plume behavior (constrains dispersion and dilution).
- Applications for disaster response planning and decision making.
- New satellite aerosol sensors should consider disaster response science needs.

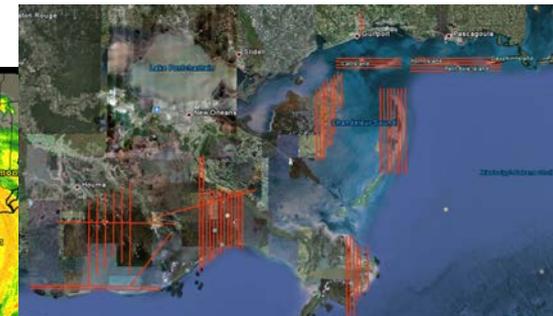


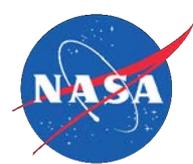
Points of contact:  
 Lead, AMOG: Ira Leifer – Bubbleology Research International  
 RamVan: Jeffrey Hall – Aerospace Corporation  
 Modeling: Marc Fischer – Lawrence Berkeley National Laboratory  
 NASA Disasters Representative: John Murray



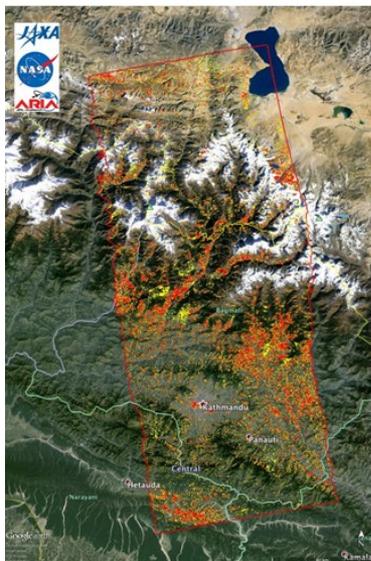
# Exercises

- HURREX2016 February 2016
  - Hurricane and Oil Spill
  - Optical and SAR data and imagery
    - Pre- and Post event
    - Ops Center Interpretative Support
    - Derived Products
    - Mapping and automated support tools and viewers
- Cascadia Rising June 2016
  - Earthquake and tsunami
  - Cascading hazards





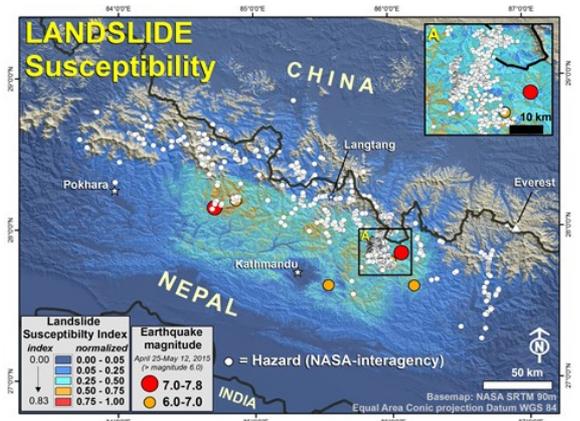
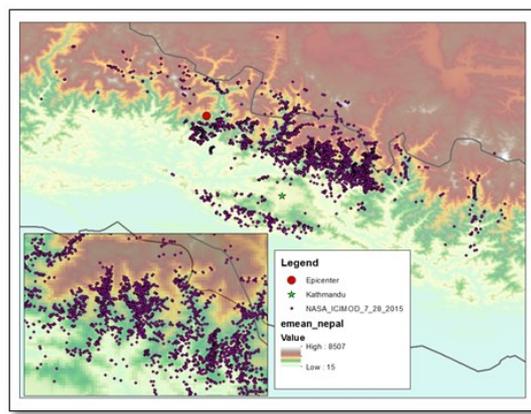
# Nepal-Gorkha Earthquake 2015 Characterizing the Hazard



## Damage Proxy Maps from ALOS-2

Highlights areas of potential damage caused by M7.8 Nepal earthquake (70 km x 180 km). Derived from SAR data from JAXA ALOS-2 (L-band)

For more information about ARIA, visit: <http://aria.jpl.nasa.gov>



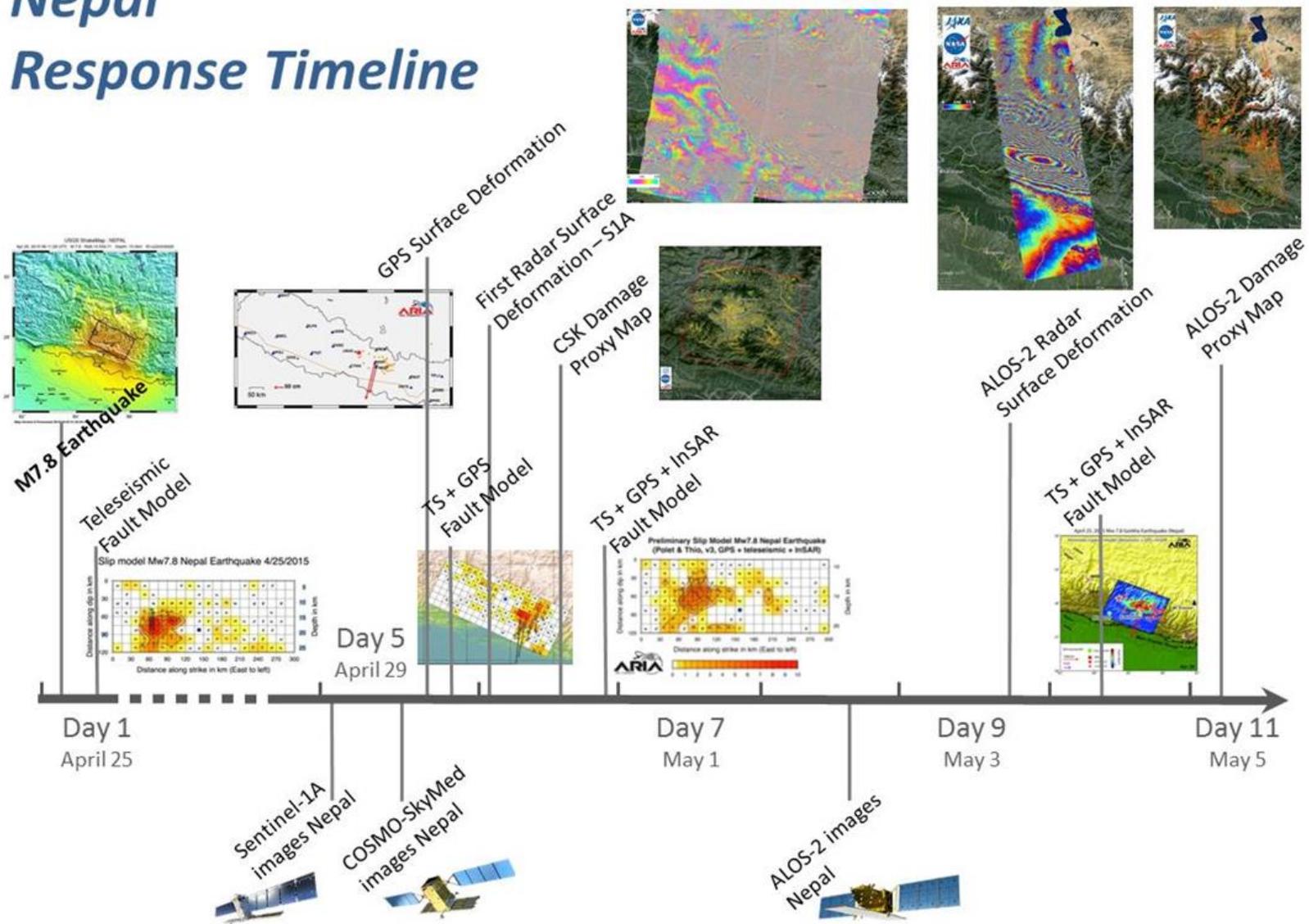
Landslide mapping using NASA, USGS and commercial imagery

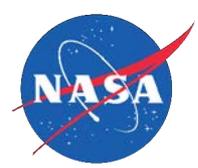
Field assessment based on reports from team of volunteer analysts

Susceptibility analyses of geohazards

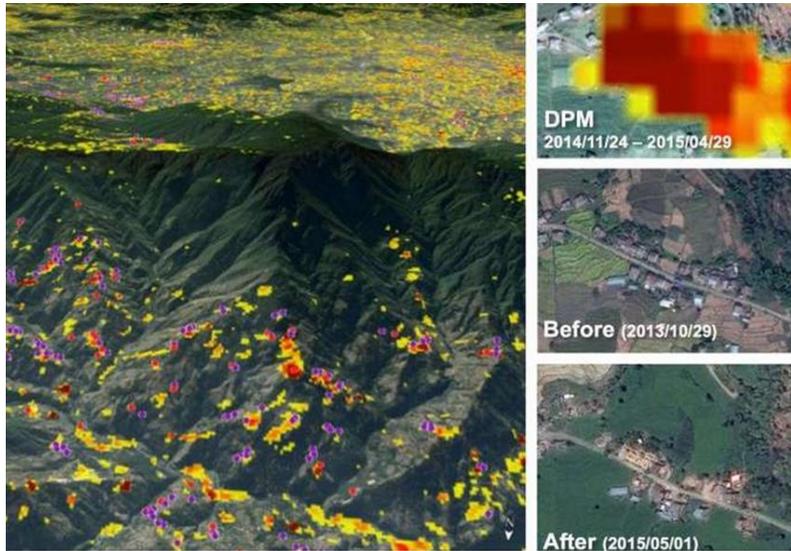


# Nepal Response Timeline





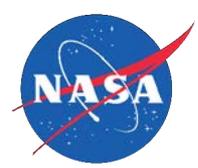
# Nepal April 2015 NASA Supporting Decision Making



“Vulnerability maps,” used to determine risks that may be present; and “damage proxy maps,” used to determine the type and extent of existing damage.



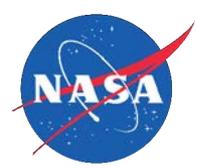
Volunteers with staff of Geospatial preparing earthquake disaster response mapping at ICIMOD



# Nepal Response

## Who Used the Products and How?

<b>Users</b>	<b>Examples of how they are used</b>
World Bank	Damage assessment for economic loss
NGA	Determine priority areas for analysis
USGS	Search for land damage and surface rupture in their fieldwork
OFDA/USAID	Damage assessment for response on the ground
ICIMOD	Search for land damage, landslides, and river blockage
GEER	Guidance for geotechnical engineer reconnaissance fieldwork
DigitalGlobe	Determine priority areas for high-resolution image acquisition
UNICEF	Exposure and damage assessment for response on the ground
ESRI	Post on their interface for sharing



# Tier 1 Midwest Flood January 2016

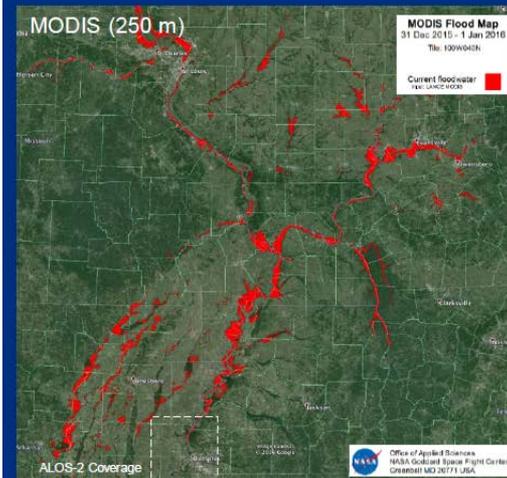
## NASA Collaboration and Key Partnerships providing End-to-end Response

Using Multiple  
Sensors, Models and  
Maps to Answer  
Critical Questions

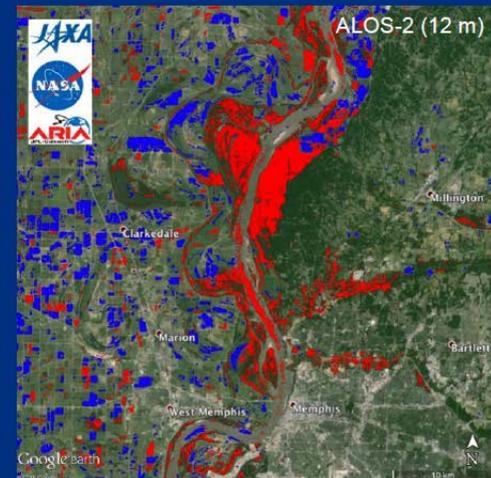
Mobilizing Resources  
to Assist Saving Lives  
and Protecting  
Property

### NASA – Remote Sensing of Flood

NASA MODIS Detections and JAXA ALOS-2 Synthetic Aperture Radar



Flood detections (red) from NASA Near Real-Time Global Flood Mapping with flood extent on January 1, 2016, courtesy of Goddard Space Flight Center.



Standing water (blue) and water-inundated vegetation (red) detected by ALOS-2 and the Synthetic Aperture Radar (SAR) at the Jet Propulsion Laboratory, January 6. Coverage area shown as dashed inset of MODIS image.



Christopher Vaughn February 4, 2016

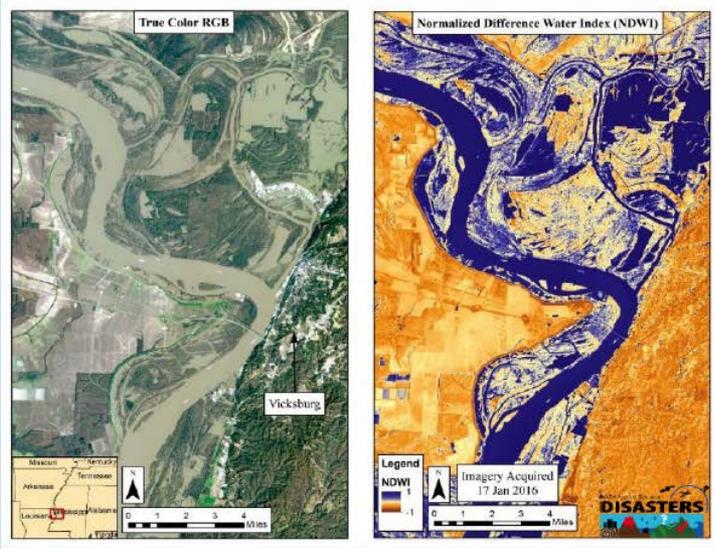


# Tier 1 Midwest Flood January 2016

## NASA Enabling End-to-end Response

### NASA - Remote Sensing of Flood

Multispectral Views from NASA's Earth Observing-1 Mission

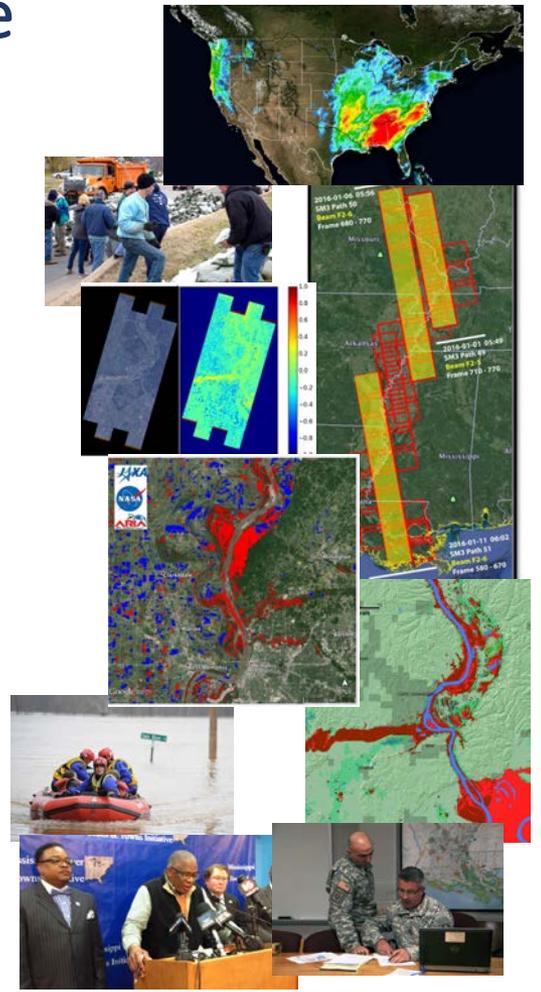


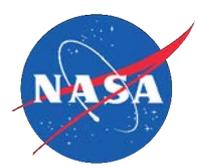
True color (left) and Normalized Difference Water Index (right) imagery derived from NASA's Earth Observing-1 mission, observed near Vicksburg, Mississippi on 17 January 2016.

NASA staff at Goddard Space Flight Center and Marshall Space Flight Center targeted collections of imagery by NASA's Earth Observing-1 (EO-1) mission.

Multispectral imaging by EO-1 provides true color imagery (left) and capabilities for derived products (right), and can also be applied to Landsat-7 and Landsat-8 missions, Aqua and Terra MODIS, Suomi-NPP VIIRS, and other imagery provided by federal agency partners, International Charter, and commercial vendors.

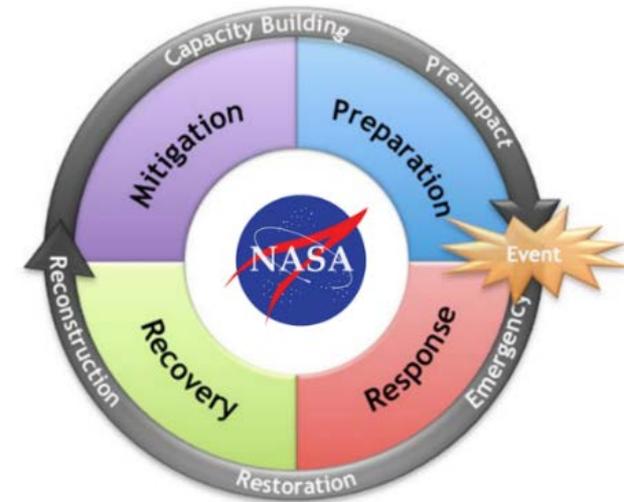
Here, true color imagery near Vicksburg, Mississippi highlights flood water (left) along the Mississippi in a visual sense, while the Normalized Difference Water Index helps to draw attention to standing water (right) in shades of blue.





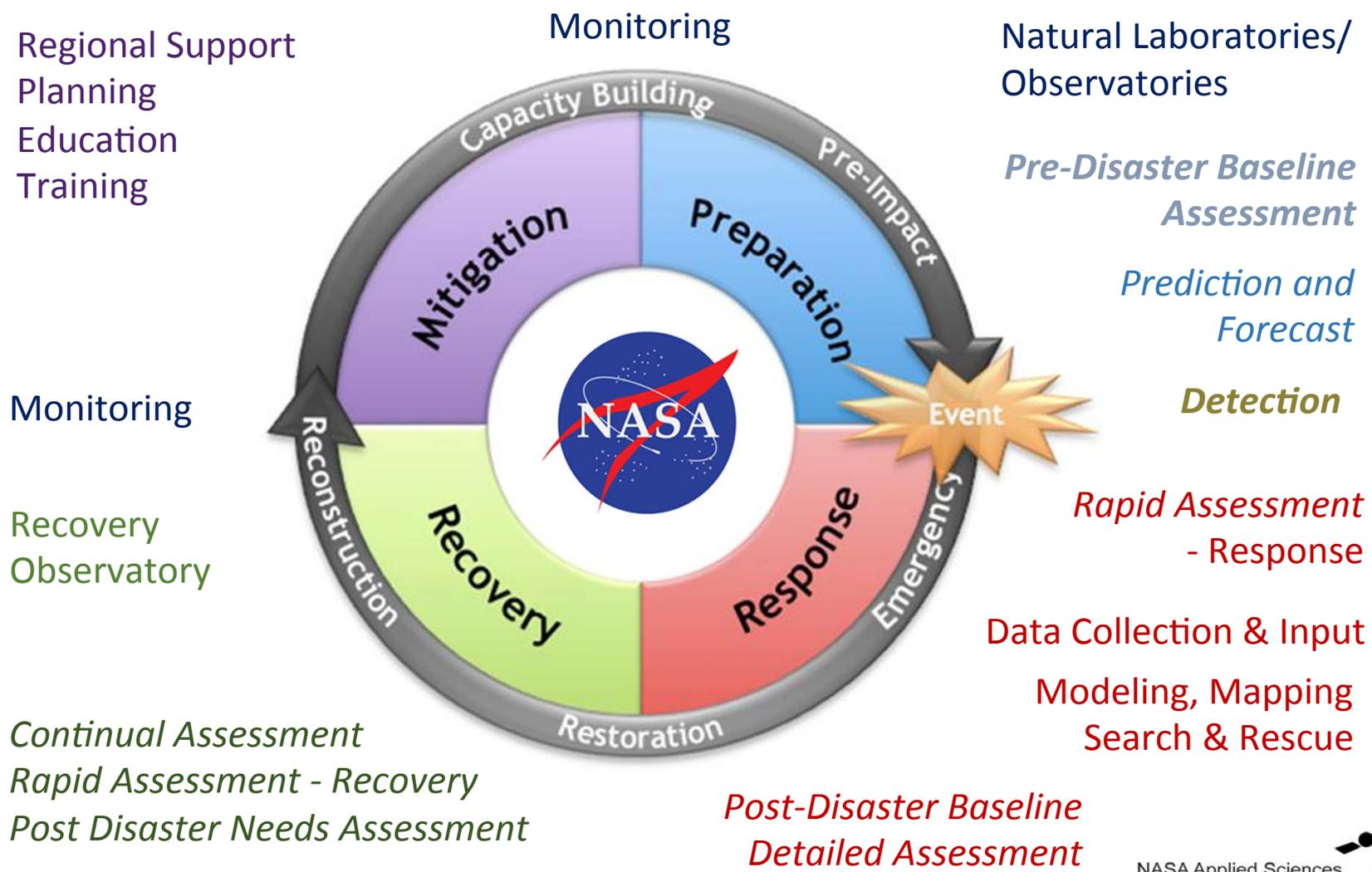
# Advancing NASA's Disaster Response

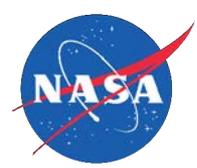
- **Disaster application science answering questions and supporting decisions** transforming EO data and research results into environmental intelligence
- **Coordination and collaboration** informing brokers, managers, and responders with critical products and services
- **Creation and leverage of partnerships** strengthening and enabling effective response throughout the disaster lifecycle





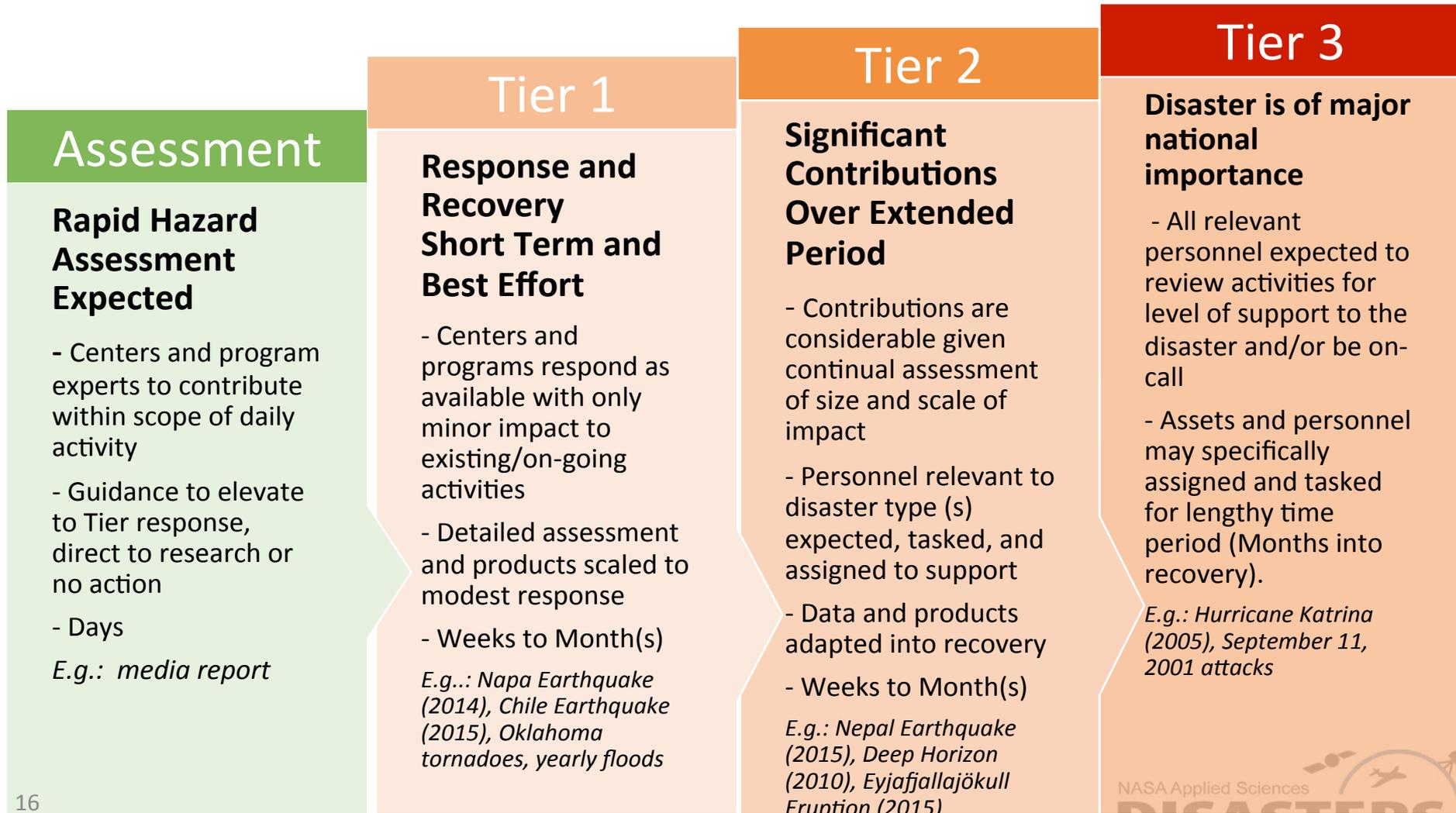
# NASA Disaster Response – Science for Disaster Risk Reduction and Resilience





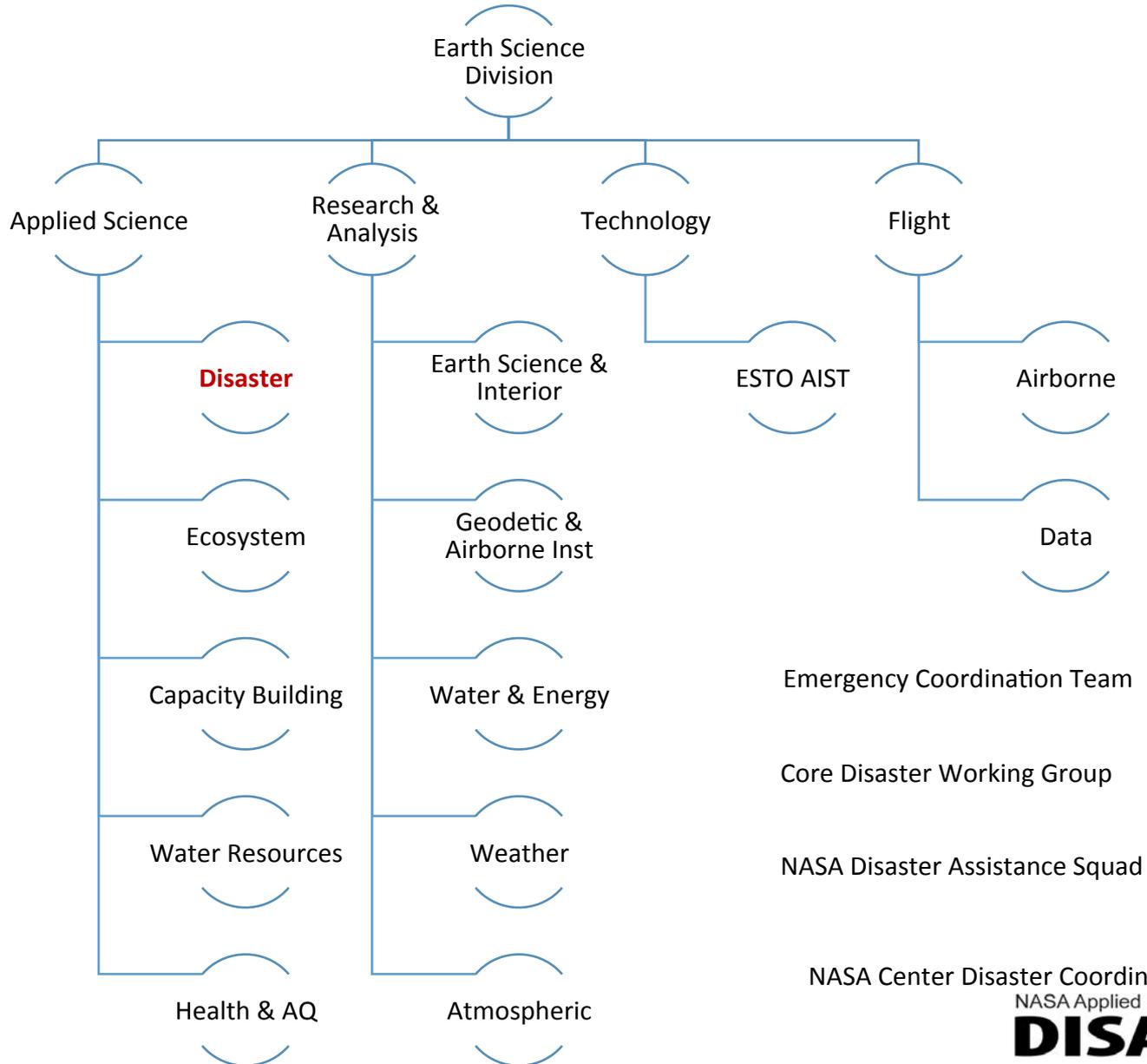
# Rapid Assessment and Tiers of Disaster Response

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





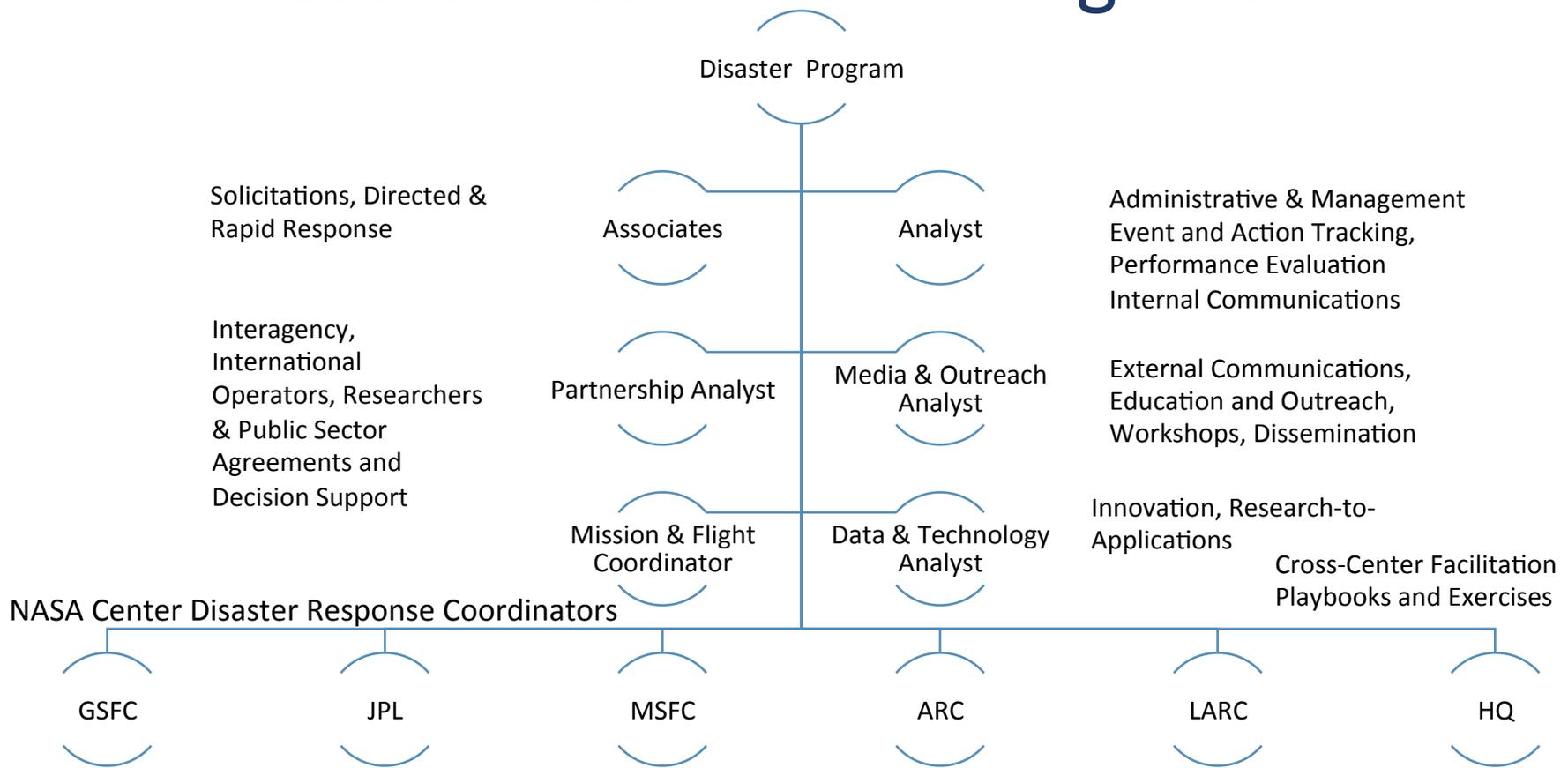
# Disaster Response Involves all ESD





# Unofficial Org Chart

## NASA ESD Disaster Risk Management



Emergency Coordination Team

NASA Disaster Assistance Squad

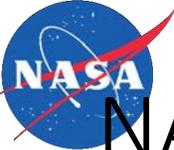
Volunteer Networks

Core Disaster Working Group

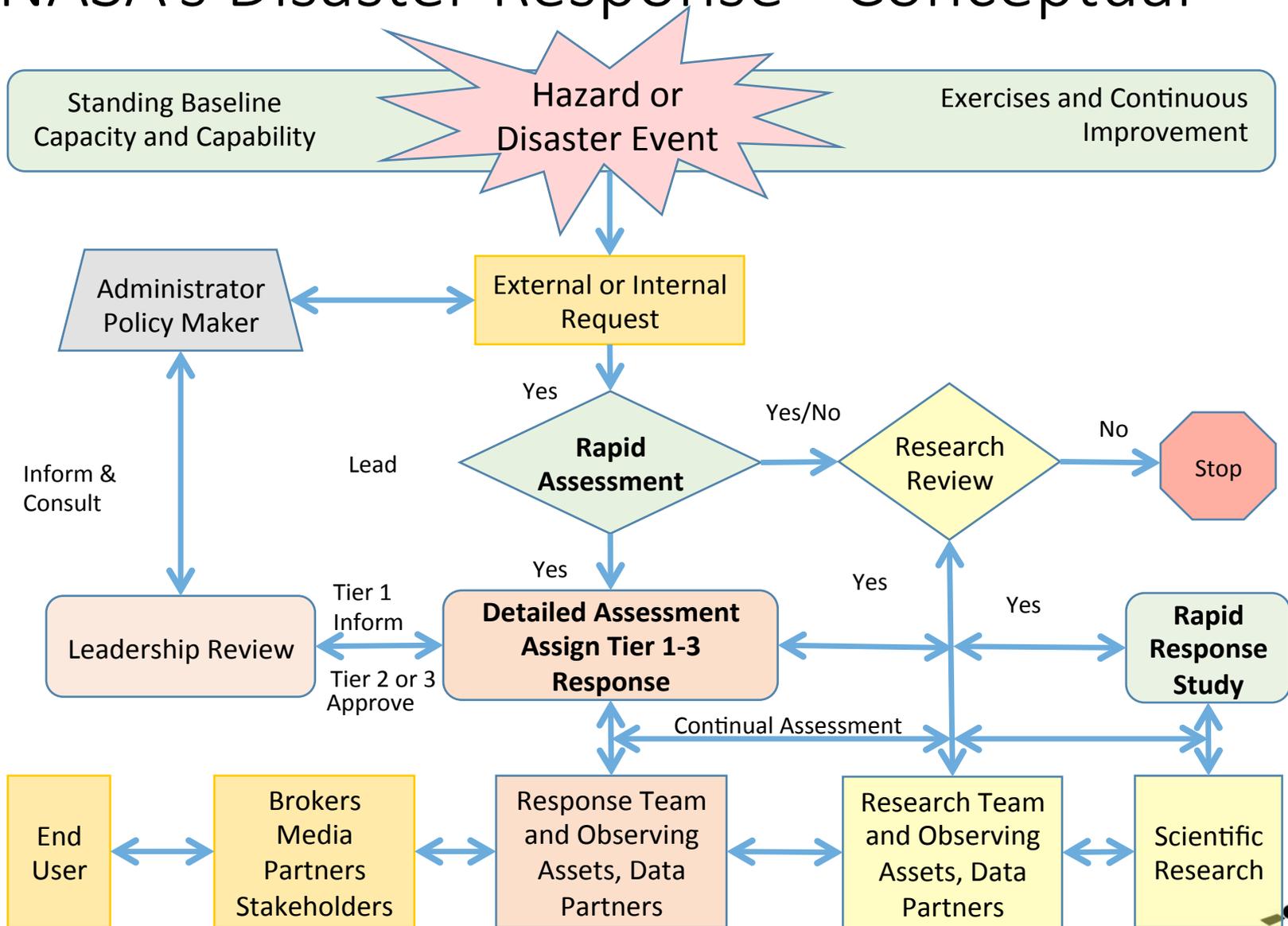
NASA PIs and Partners

Citizen Science/Social Media





# NASA's Disaster Response - Conceptual



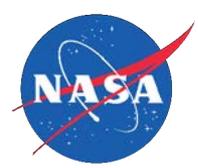


# New Frontier of Earth Observing Missions and Instruments Serve Resilience

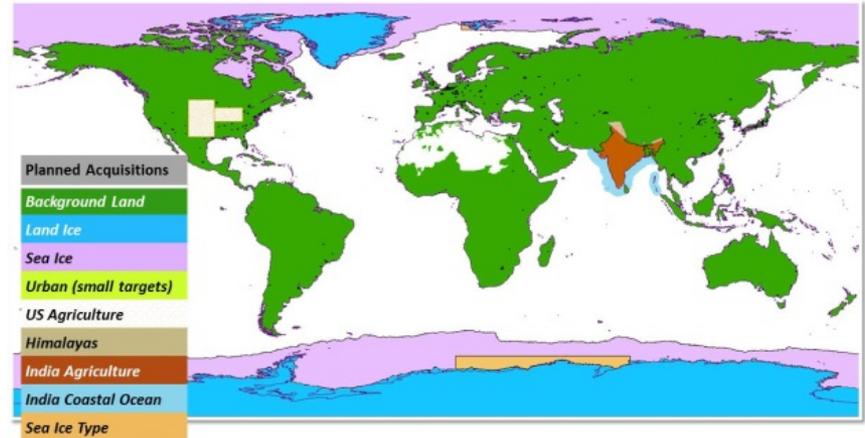
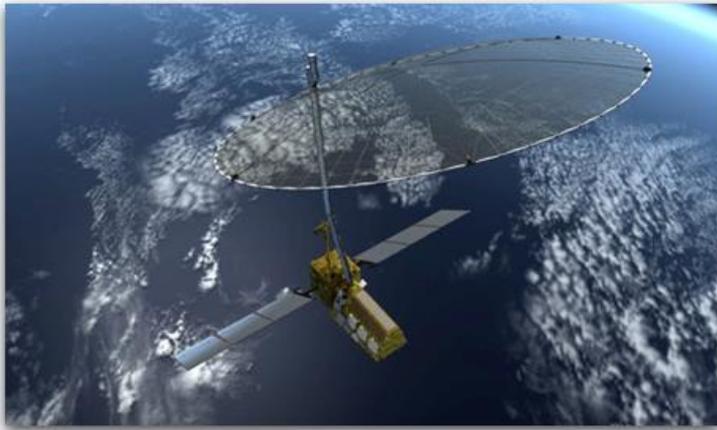
Disaster Program supporting

- Application workshops,
- Trainings, certifications
- Partnerships to promote optimal use and integration of satellite, aviation and space station capabilities





# NASA and Mission Partnerships - NISAR\* Disaster Response and Resilience



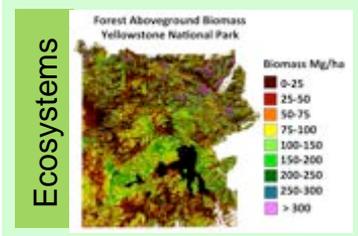
NISAR will change the way the world shares data and provide advanced radar imaging that it will capture uniquely the Earth in motion

\* NASA and ISRO (the Indian Space Research Organisation) Synthetic Aperture Radar *Mission Concept to Launch in 2020*

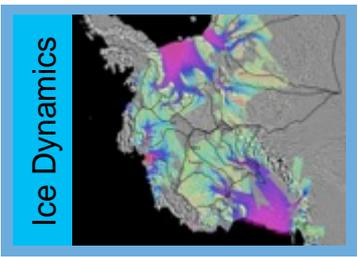


# NISAR\* Science Traceability

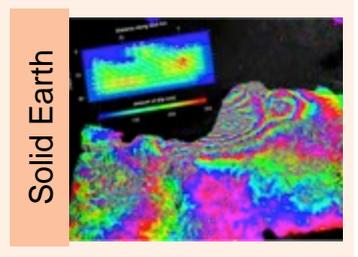
- Biomass, disturbance, agriculture
- Response to climate change & CO<sub>2</sub>



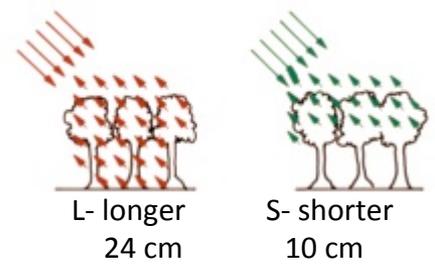
- Ice velocity
- Response to climate change & sea level rise



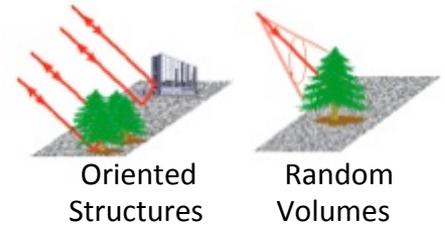
- Surface deformation, disruption
- Hazards response, water resources



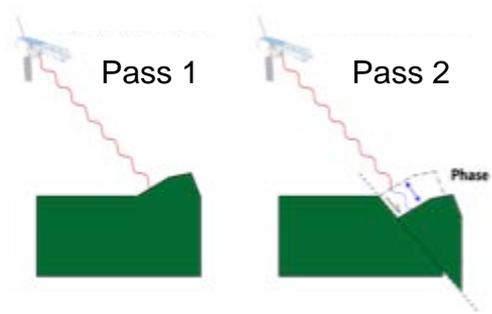
## L- and S-band Wavelength



## Polarimetry



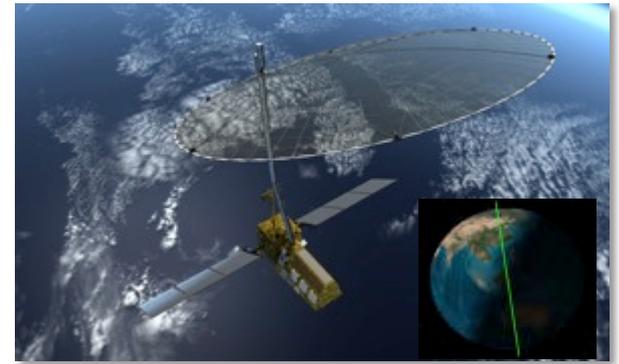
## Repeat Pass InSAR

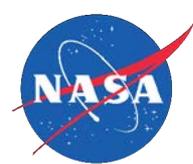


- Measurement accuracy
- Time-series-enabled science

- 12-day exact repeat orbit
- 5-10 m resolution
- Global coverage
- 3 years of observations

- Swath > 240 km
- 747 km altitude, circular, 98 deg. inclination, sun-sync (6AM-6PM)
- Pointing control < 273 arcsec
- Orbit control < 500 m
- > 30% observation duty cycle
- Left/Right pointing capability



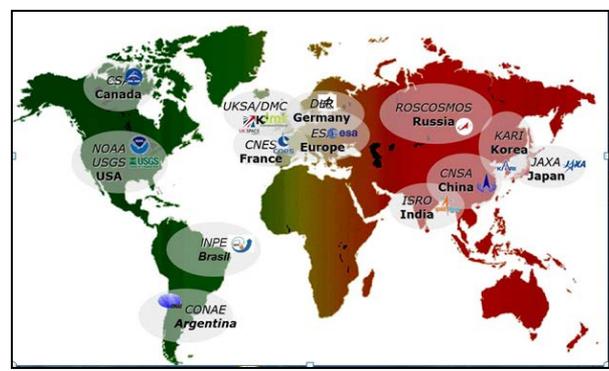


# Coordination and Collaboration

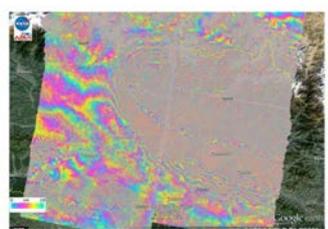
The Disasters Program is exploring innovative partnerships for providing

- Scientific and technical expertise
- Data and products, and
- Decision support

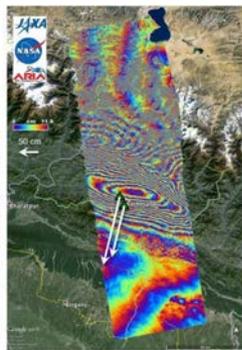
to assist shared emergency-response stakeholders.



New Look at Earth Surface Deformation from Nepal Earthquake



Data from ESA Sentinel-1A  
Acquired 5 days after the earthquake



Data from JAXA ALOS-2 &  
Caltech GPS stations  
SAR acquired 6 days after the earthquake





# Summary

- **NASA Disaster Response**
  - Sponsoring application science (ROSES)
    - Solicitations, Rapid Responses, Workshops and Training
  - Mobilized Response
    - Monitoring hazard impacts
    - Mapping Damage and Impacts (damage proxy maps, models)
    - Rapid dissemination of data and model products
    - Interfacing with key stakeholders (e.g. Wildfire Community, NIFC) during the response effort



# Conversation with Wildfire Program

- Coordination Team interested in Wildfire Program Roadmap and options for alignment with Ecosystem and Disaster Programs
- Engagement with Disaster Response Plan
  - Playbook for Wildfire Response and cascading hazards e.g. landslide and flood
  - Disaster Portal coordination
  - Rapid Response
  - Interagency Partnerships
  - Low-latency data and models



# My Forest Ranger

