


Hazard Assessment with SAR: What to Expect from the NISAR Mission

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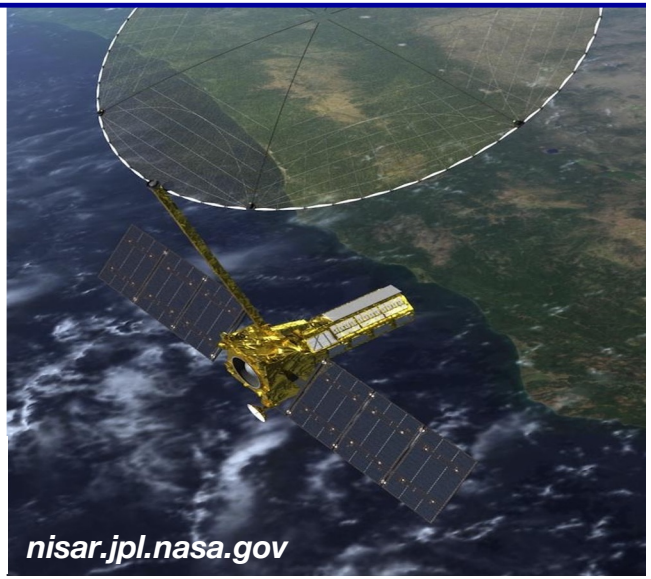
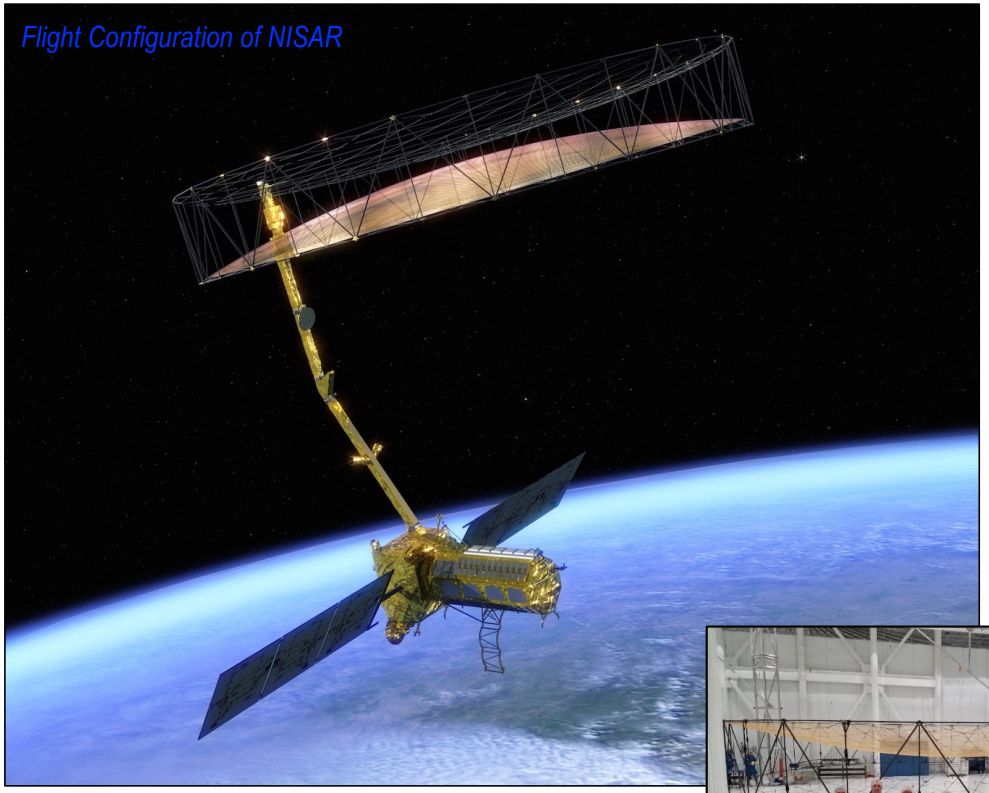
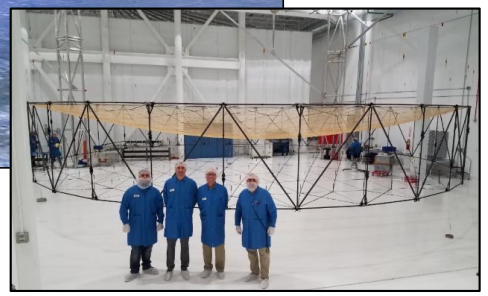


Jet Propulsion Laboratory
California Institute of Technology

NISAR – NASA ISRO SAR Mission

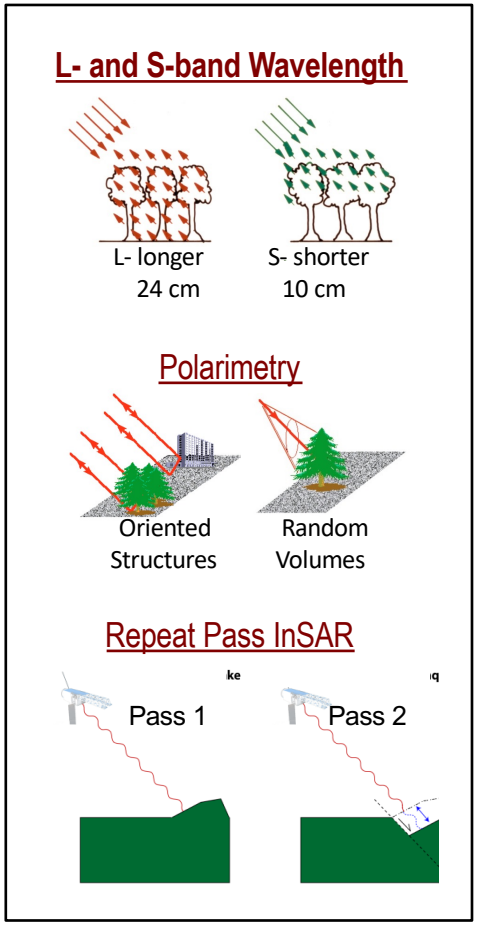
- **Collaboration of NASA and the Indian Space Research Organization (ISRO)**
- **Launch in Jan. 2024**
- **Two radars**
  - L-band (24 cm) global land + sea ice – higher coherence than C-band
  - S-band (10 cm) India's AOIs
- **12 day orbit repeat interval**
- **Product delivered in ~24 hours**
  - 5 hours for disaster response
- **Data is free and open to all**
  - Hosted at the Alaska Satellite Facility



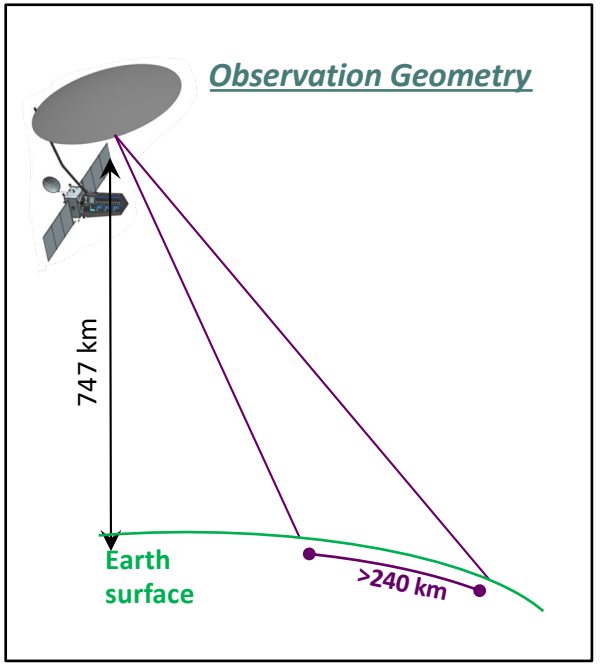


NISAR instrument Characteristics

NISAR Characteristic:	Enables:
L-band (24 cm wavelength)	*Low temporal decorrelation and foliage penetration*
S-band (9 cm wavelength)	*Sensitivity to lighter vegetation*
*SweepSAR technique with **Imaging Swath > 240 km***	*Global data collection*
*Polarimetry (Single/**Dual**/Quad)*	*Surface characterization and biomass estimation*
12-day exact repeat	*Rapid Sampling/time series*
3 – 10 meters mode-dependent SAR resolution	*Small-scale observations*
Pointing control < 273 arcseconds	*Deformation interferometry*
Orbit control < 500 meters	*Deformation interferometry*
***L**/**S**-band > **50**/**10**% observation duty cycle*	*Complete land/ice coverage*
Left-Looking	*Uninterrupted time series; More Antarctic coverage*

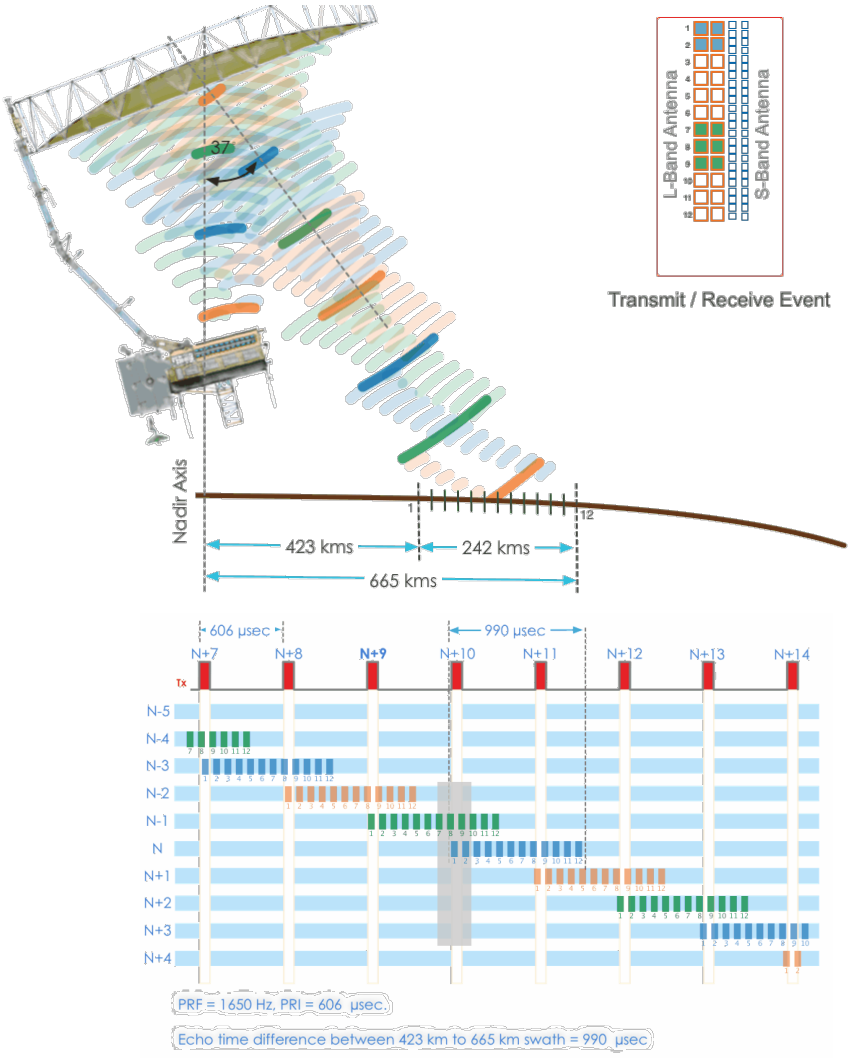


6 AM / 6 PM Orbit
98.5º inclination
Arctic Polar Hole: 77.5 Lat
Antarctic Polar Hole: -87.5 Lat



Measurement Technique
SweepSAR

- **SweepSAR**
  - On Transmit, illuminate the entire swath of interest
  - On Receive, steer the beam in fast time to follow the angle of the echo coming back to maximize the SNR of the signal and reject range ambiguities
  - Allows echo to span more than 1 Inter-Pulse Period (IPP)
- **Consequences**
  - 4 echoes can be simultaneously returning to the radar from 4 different angles in 4 different groups of antenna beams
  - Each echo needs to be sampled, filtered, beam-formed, further filtered, and compressed
  - On-board processing is not reversible – Requires on-board calibration before data is combined to achieve optimum performance



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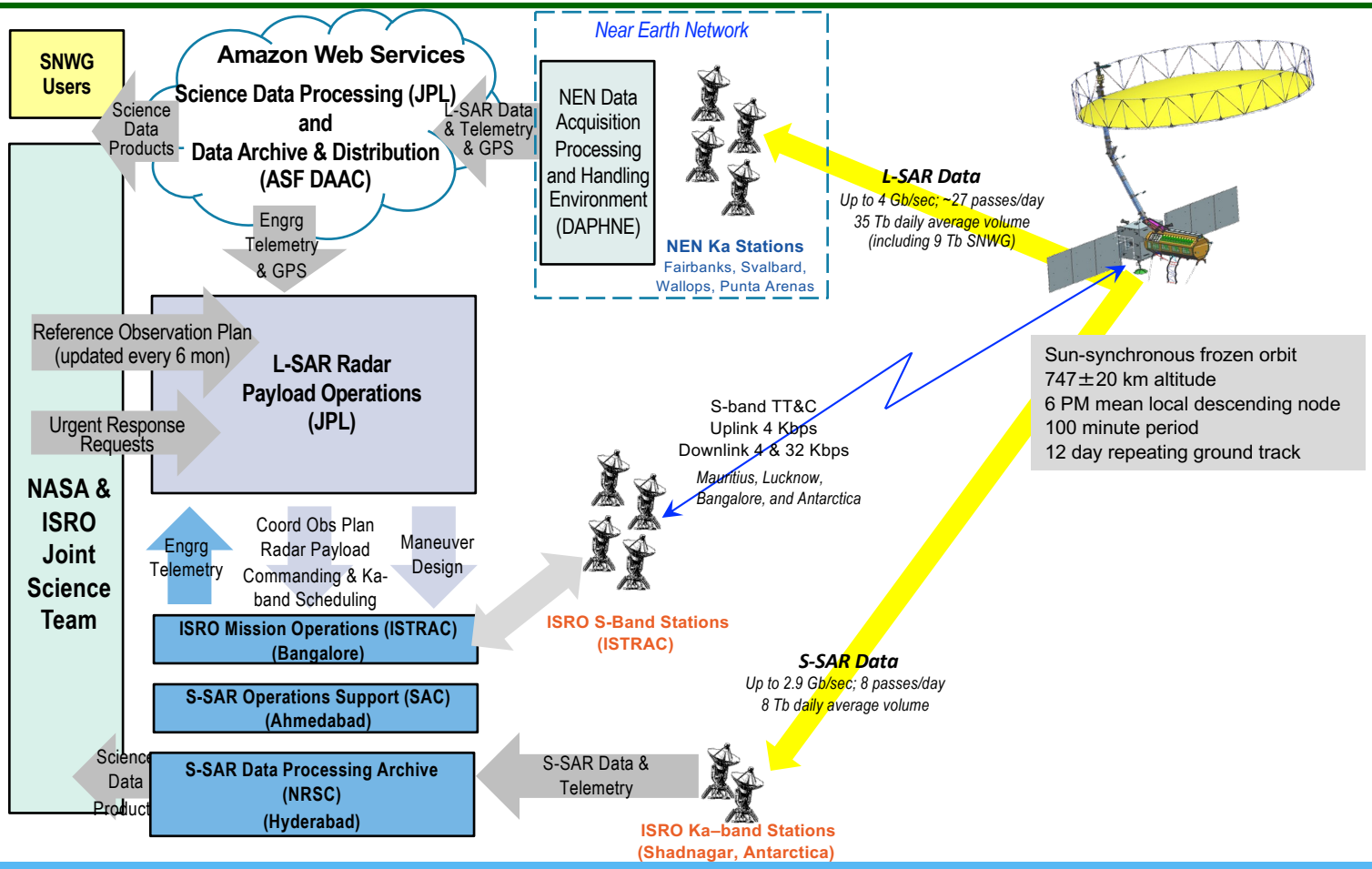
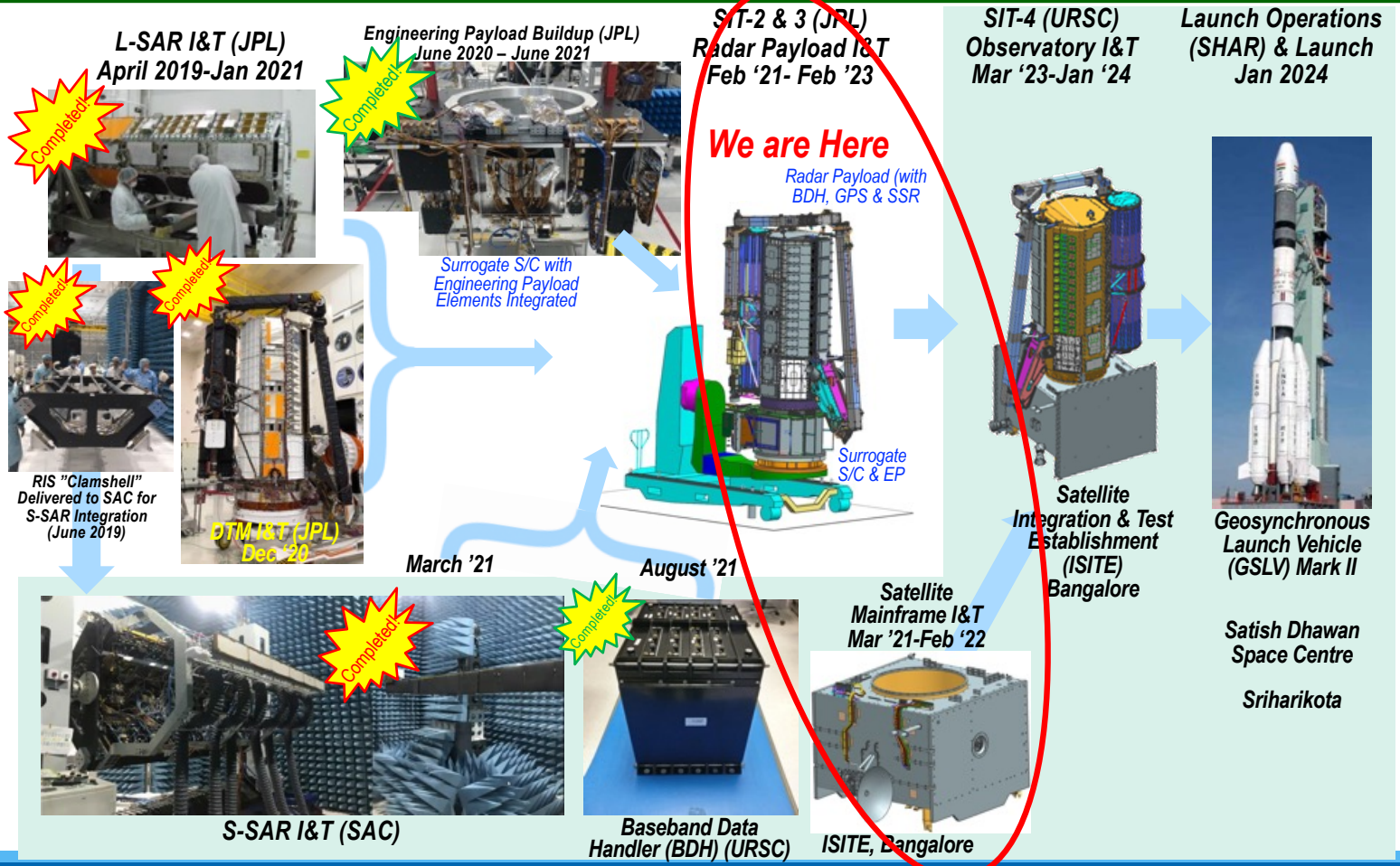
NISAR Operations Overview



NISAR Development Status

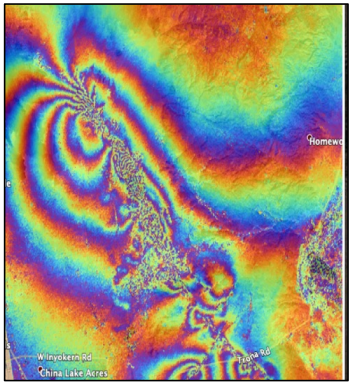


Mission Status

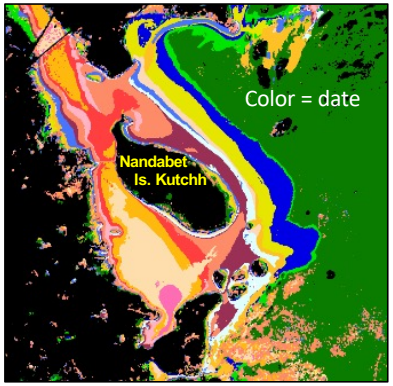
Flight Boom currently being integrated with flight model radar structure; Flight Reflector integration late May 2022

Solid Earth, **Ecosystems**, **Cryosphere**
Science and Applications Mission

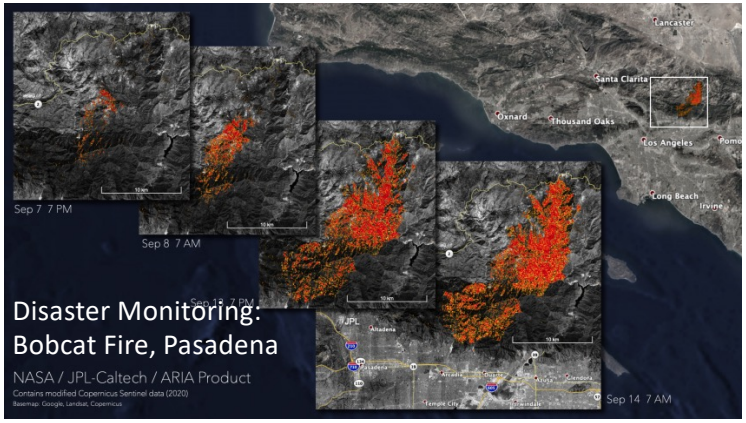
NISAR Science



Earthquake Dynamics, Ridgecrest



Wetland Inundation, India

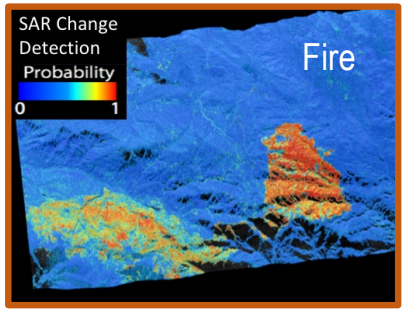


Disaster Monitoring: Bobcat Fire, Pasadena
NASA / JPL-Caltech / ARIA Product
Contains modified Copernicus Sentinel data (2020)

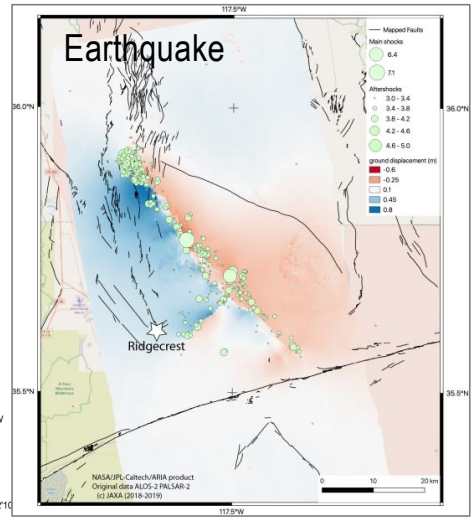
- **Dynamics of Ice: Ice sheets, Glaciers, and Sea Level**
  - *Will there be catastrophic collapse of the major ice sheets, including Greenland and West Antarctic and, if so, how rapidly will this occur?*
  - *What will be the resulting time patterns of sea-level rise?*
  - *How are alpine glaciers changing in relation to climate?*
- **Ecosystems and Biomass Change**
  - *How do changing climate and land use in forests, wetlands, and agricultural regions affect the carbon cycle and species habitats?*
  - *What are the effects of disturbance on ecosystem functions and services?*
- **Solid Earth Deformation**
  - *Which major fault systems are nearing release of stress via strong earthquakes?*
  - *Can we forecast future eruptions of volcanoes?*
  - *What are optimal remote sensing strategies to mitigate disasters and monitor/manage water and hydrocarbon extraction and use?*
  - *Where is subsidence occurring, by how much, and due to what processes?*
- **Coastal Processes**
  - *What is the state of important mangroves?*
  - *How are Indian coastlines changing?*
  - *What is the shallow bathymetry around India?*
  - *What is the variation of winds in India's coastal waters?*

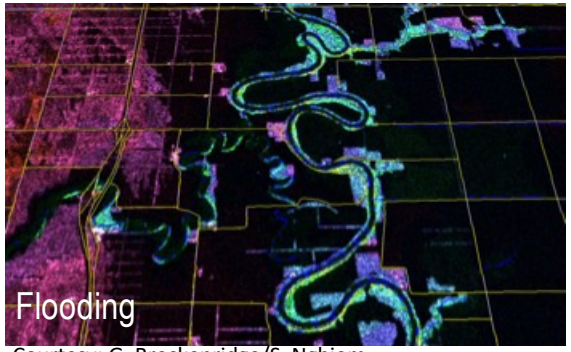
Hazard Response

NISAR Hazard Applications

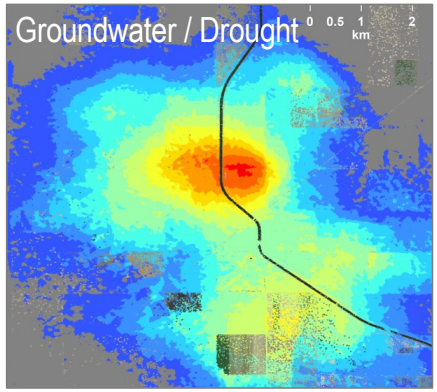


Courtesy: UAVSAR Project

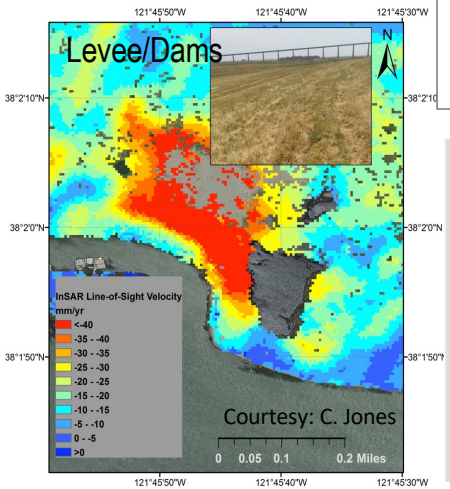


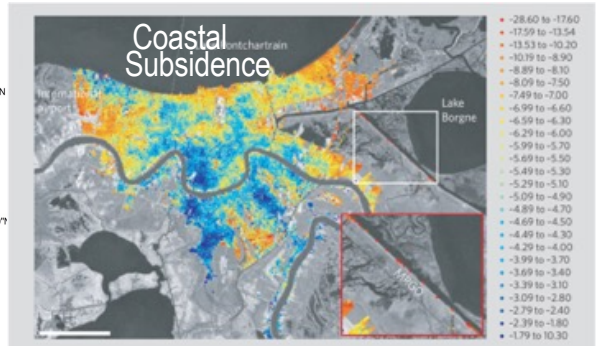


Courtesy: G. Breckenridge/S. Nghiem

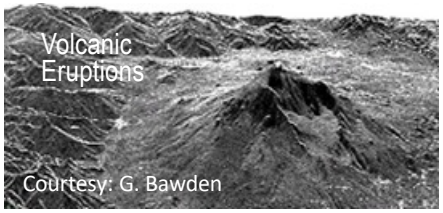


Courtesy: C. Jones

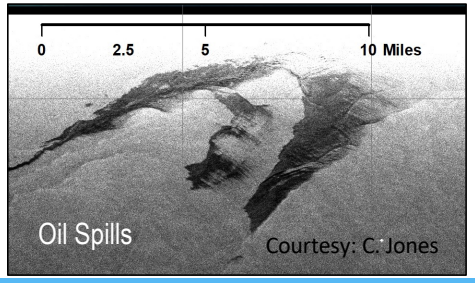


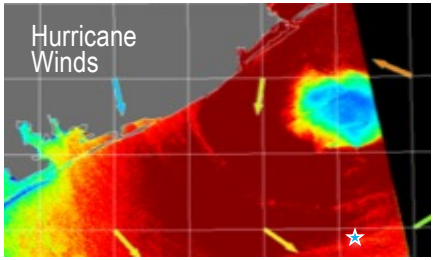


Dixon et al, Nature 2006

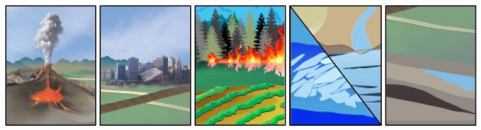


Courtesy: S.-H. Yun



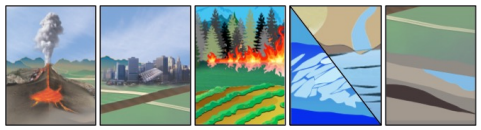


Courtesy: G. Bawden



Societal Challenges / Applied Science

Challenge	Benefit Through Regular SAR Monitoring of:
Climate Risks and Adaptation	- Ice sheet/sea-ice dynamics; response to climate change - Coastal erosion and shoreline migration
Global Food Security	- Soil moisture and crop growth at agricultural scale - Desertification at regional scales
Freshwater Availability	- Aquifer use/extent regionally - Water-body extent changes - Glaciers serving as water sources
Human Health	- Moisture and vegetation as proxy for disease and infestation vectors
Disaster Management & Hazard Response	- Regional building damage and change assessment after earthquakes - Earthen dams and levees prone to weakening - Volcanoes, floods, fires, landslides
Urban Management and Planning	- Urban growth through coherent change detection - Building deformation and urban subsidence
Human-activity Based Climate Change	- Deforestation's influence on carbon flux - Oil and gas reservoirs



Urgent Response Capability

NISAR tasking & processing systems provide low latency downlink & processing for disaster response, including retasking to obtain new scenes in extreme cases (e.g., ocean scenes for major hurricanes)

Latency goal: 5 hours from acquisition to product delivery

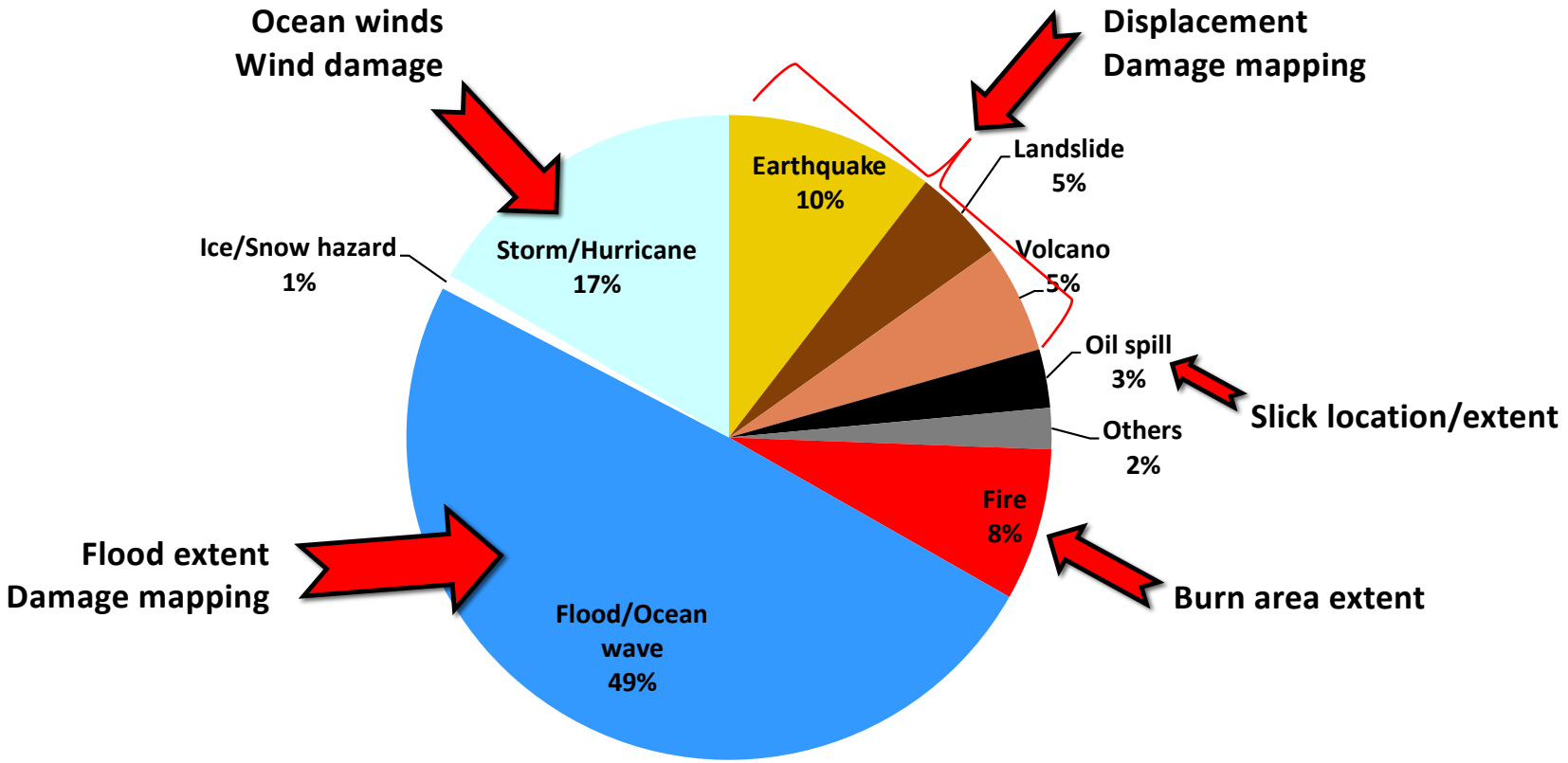
Major earthquakes (7+ & USGS PAGER red/orange) will automatically trigger requests, others by request

- Most land scenes will already be in acquisition plan, so they will be tagged for immediate expedited processing upon downlink.
- New scenes (e.g., ocean) require retasking
  - Forewarned events can be requested in advance
  - Gulf of Mexico & Caribbean Sea are in standard plan
  - Best case, requests received by Weds. can be acquired on Saturday

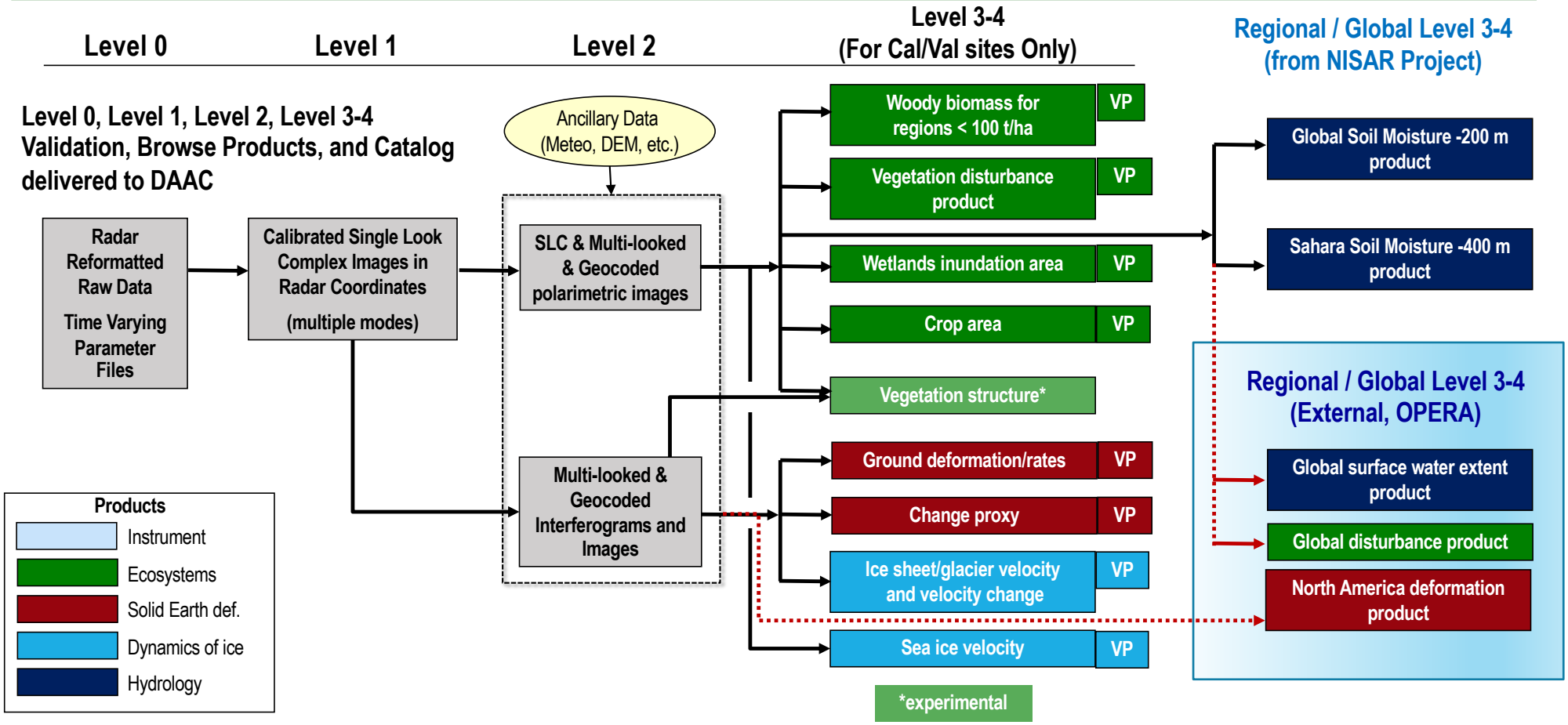
Topic	Event	Classification
Geological Hazards	Volcano Eruption	Catastrophic Event, Automatable
	Earthquake	Catastrophic Event, Automatable
	Landslide	Catastrophic Event, Manual
	Other Geological Hazards	Catastrophic Event, Manual
Critical Infrastructure	Levee, Dam, Bridge Failure	Catastrophic Event, Manual
	Industrial Accident	Catastrophic Event, Manual
	Secondary impact of other events	Catastrophic Event, Automatable
Underground Reservoirs	Mine, Cavity Collapse	Catastrophic Event, Manual
	Induced Seismicity	Catastrophic Event, Automatable
Surface Hydrology	Storm Surge Flooding	Forewarned Disaster
	Riverine Floods	Forewarned Disaster
	Ice Jams	Forewarned Disaster
Ecosystems	Forest Fires	Catastrophic Event, Automatable
	Agriculture, Secondary Impact	Forewarned Disaster
Maritime Hazards	Oil Spills	Catastrophic Event, Automatable
	Oceanic Storm (Hurricane, Typhoon, Other)	Forewarned Disaster
	Icebergs	Forewarned Disaster
	Tsunami	Catastrophic Event, Manual
	Ship or Aircraft Distress – Lost at Sea - Maritime Accident	Catastrophic Event, Manual

EXPECT NISAR RESPONSE FOR THESE EVENTS

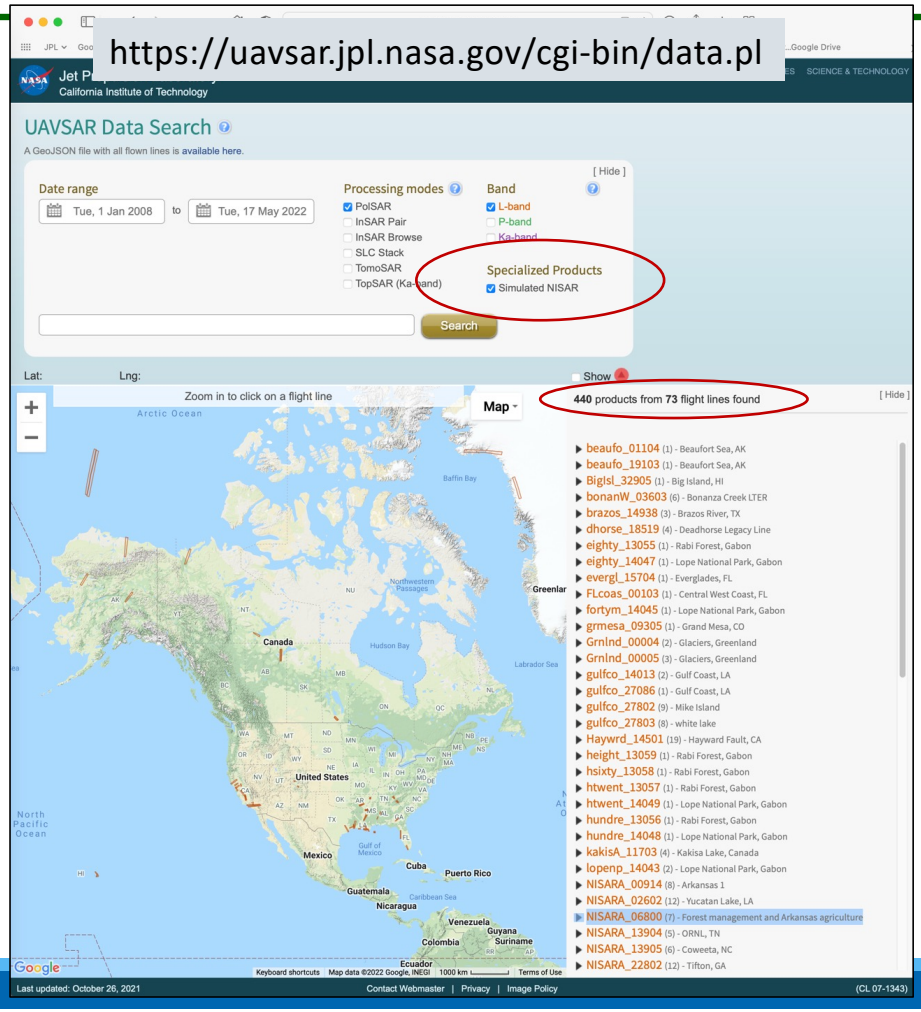
Hazard-relevant Information from SAR



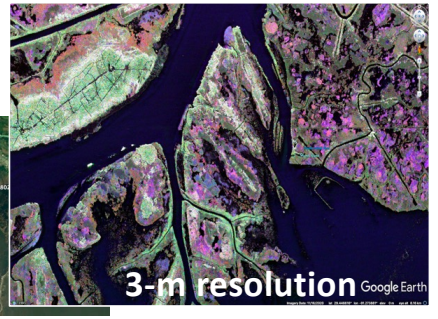
NISAR Science & Information Products



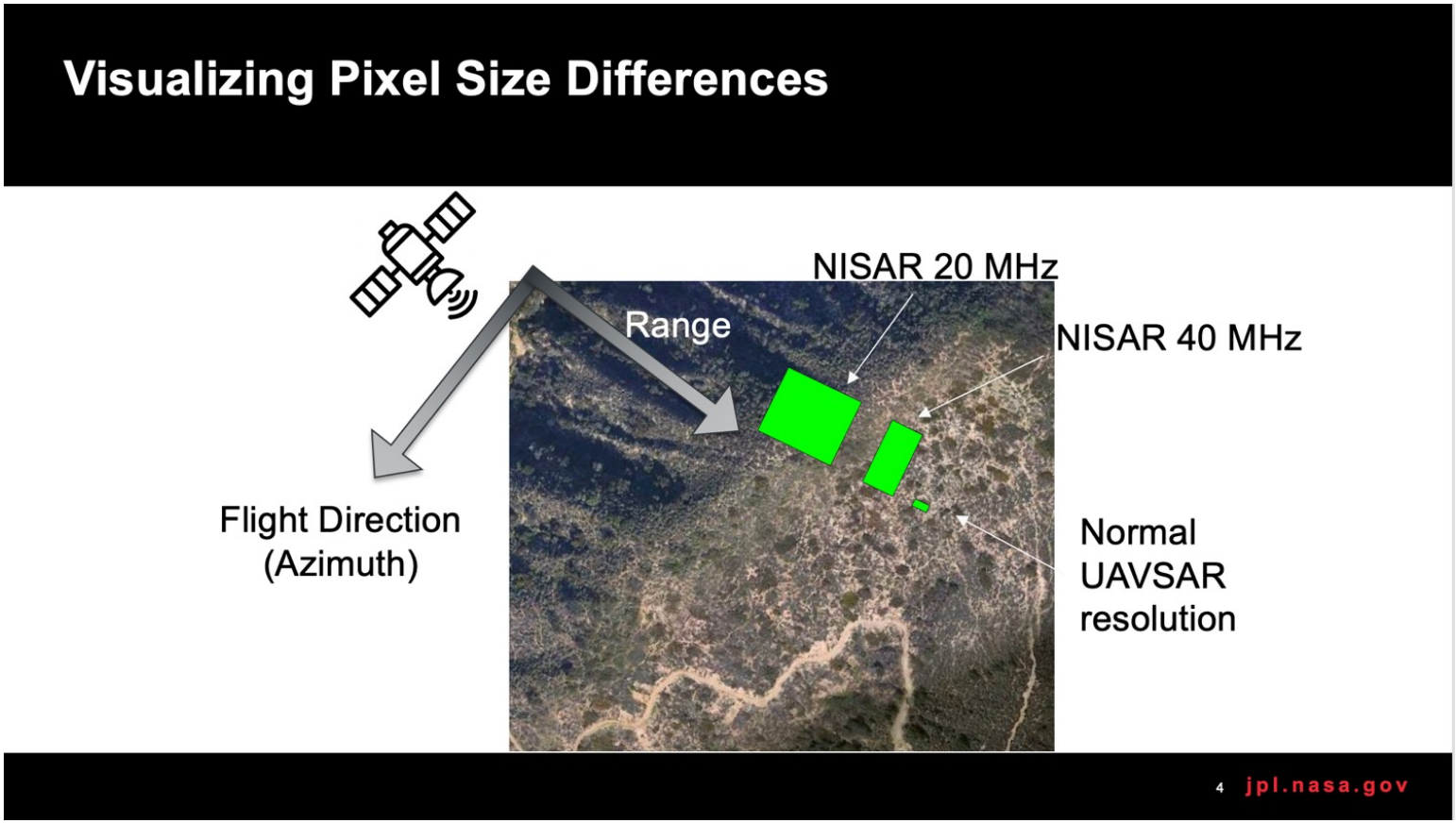
NISAR-Like Data from L-band UAVSAR Instrument



Full Resolution UAVSAR

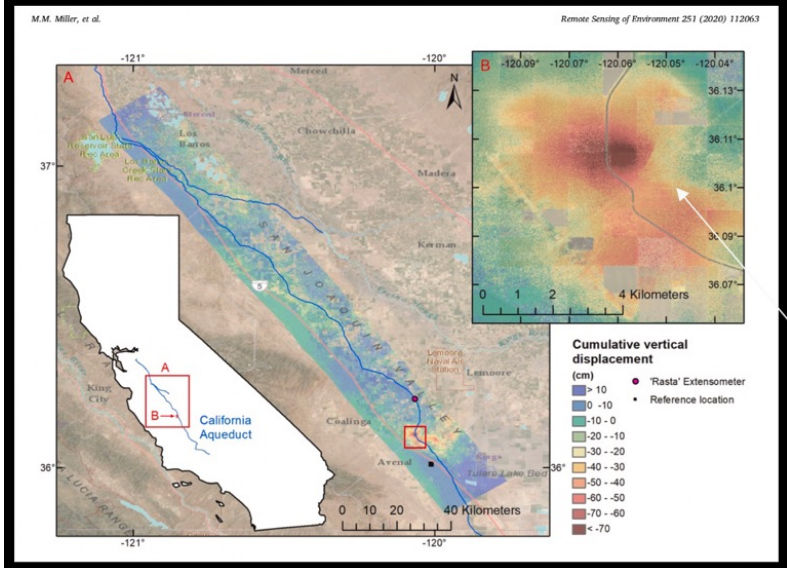


NISAR-Like UAVSAR Data



California Central Valley
Groundwater extraction, subsidence impact to the California Aqueduct

Aqueduct Subsidence



Miller, 2020

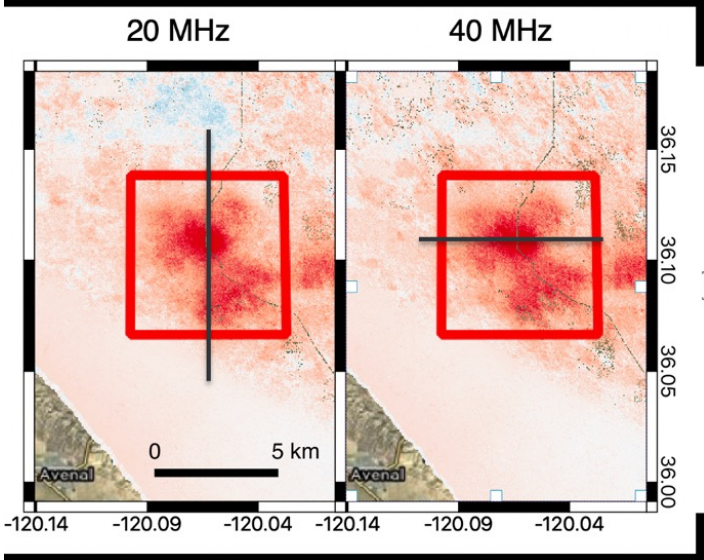
Questions:

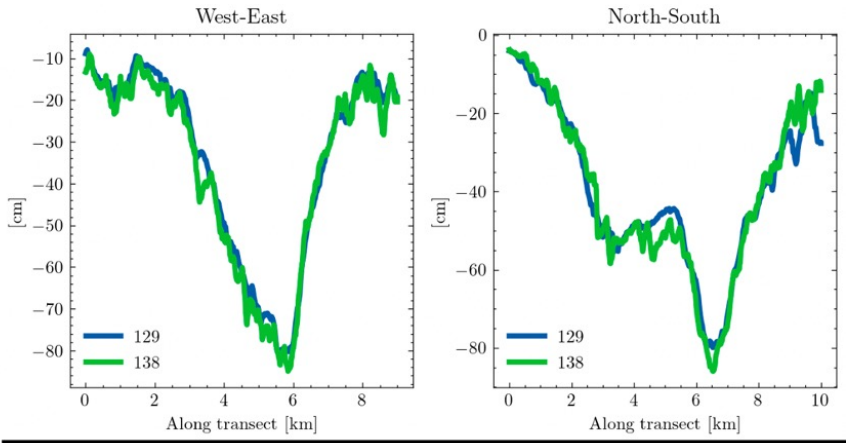
1. Will coarser NISAR underestimate subsidence?

-104 cm subsidence

At L-band, there is little difference between 20 MHz and 40 MHz for this deep subsidence bowl.

Aqueduct Subsidence Feature



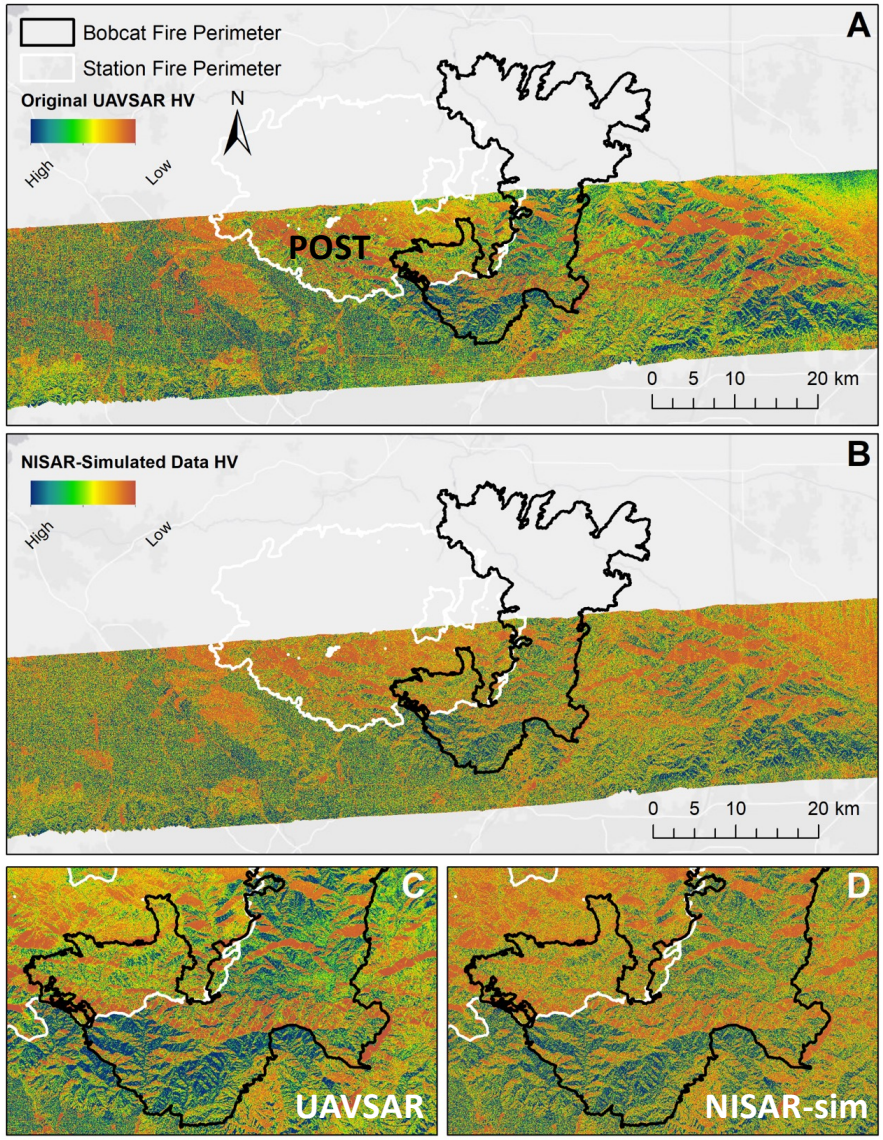


Used 4 connections in the interferogram network (temporal baseline varied)

PRE-VS-POST FIRE FUEL LOAD

Bobcat Fire (pre)
vs.
Station Fire (post)

Southern California



A. Original UAVSAR HV Image

Green/Blue areas show more volume scattering from vegetation – relates to fuel load

Orange/red (low HV) follow earlier fire's burn area outline

B. NISAR-Like HV Image

Qualitatively the same

Paper in prep: An, K., Jones, C. E., & Lou, Y (2022). Developing a detection and monitoring framework for wildfire regimes with L-Band Polarimetric SAR.

NISAR Applications White Papers

2/26/2019

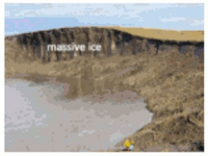
Soil Moisture and Water Resources

PDF, (1.31 MB)

2/26/2019

Damage Mapping

PDF, (3.66 MB)



2/26/2019

Changes in Permafrost

PDF, (797 KB)

2/26/2017

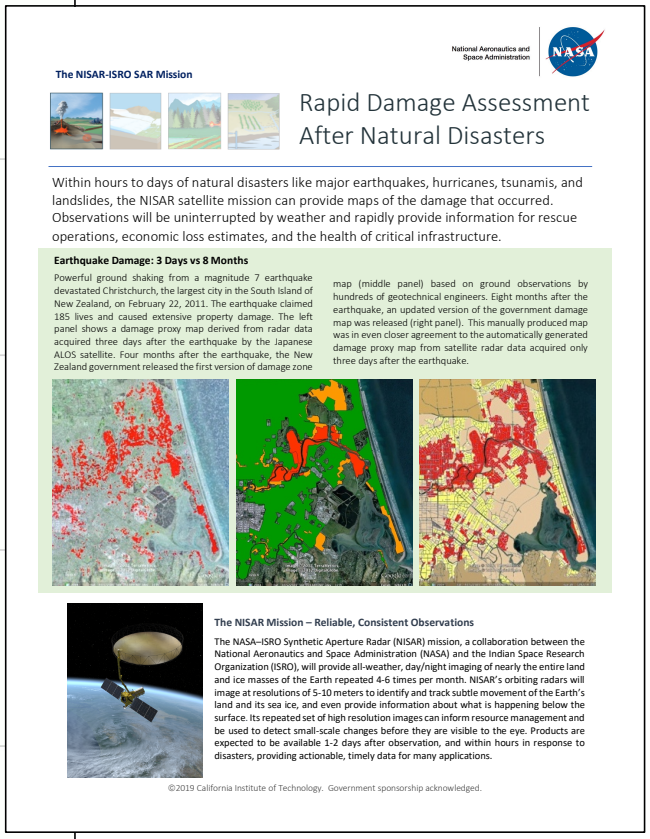
Sinkholes and Cavern Collapse

PDF, (2.01 MB)

2/26/2017

Volcanic Hazards

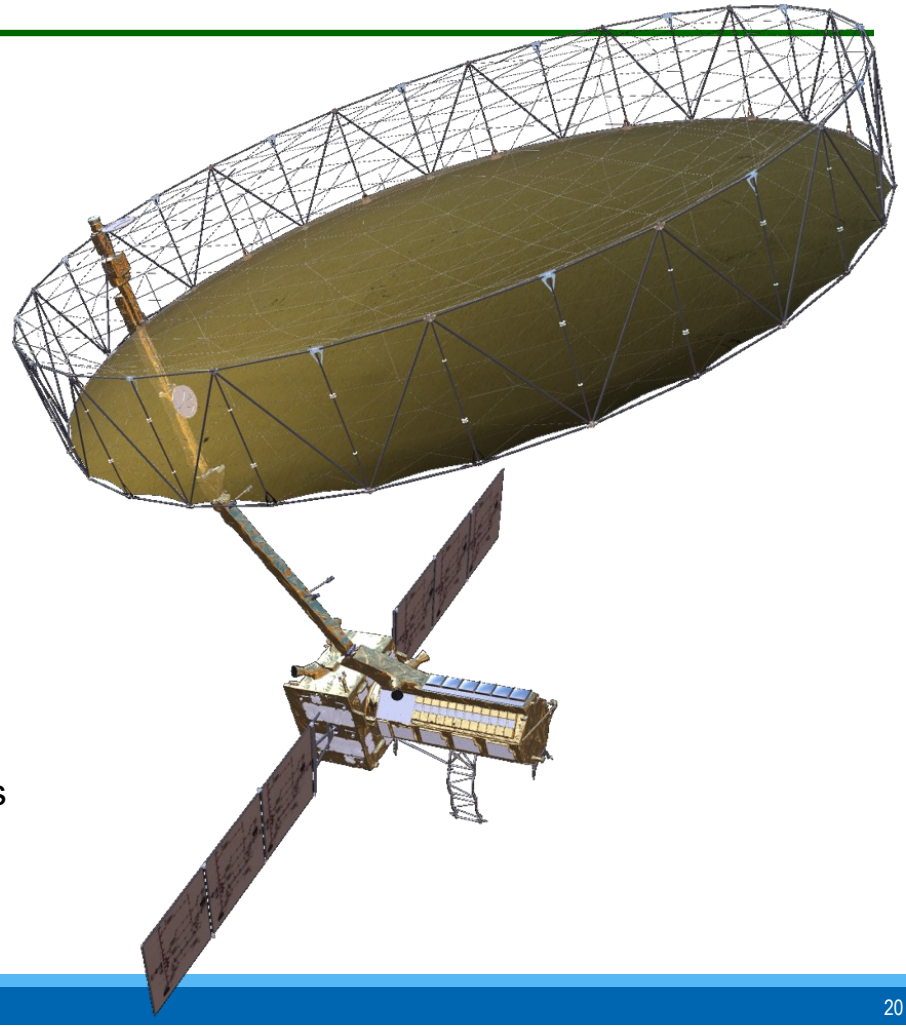
PDF, (1.62 MB)



http://nisar.jpl.nasa.gov/applications

Summary

- NISAR will have
  - Consistent global L-band imaging
  - Polarimetric, interferometric modes
  - Dual frequency L and S-band primarily over India
  - Global L0-L2 product suite of interferometric and polarimetric products, *free and open*
- NISAR mission addresses key questions in solid Earth, ecosystems, cryospheric, and hydrological sciences
- Same data is used for many applications (resource management, risk reduction, situational awareness)
- Disaster response and support for applications are a priority
- NISAR-like data are available to evaluate NISAR's capabilities for different applications.



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