NASA-ISRO Synthetic Aperture Radar (NISAR) Mission

NISAR Applications

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Jet Propulsion Laboratory
California Institute of Technology

Talk Outline

- Mission Status and Overview
- Applications in Water Resources
- Community Resources
- Early Adopter Program

NISAR
NASA - ISRO SAR Mission

Partnership between NASA and ISRO-India

Dual frequency SAR
NASA: L-band @ 24 cm
ISRO: S-band @ 10 cm

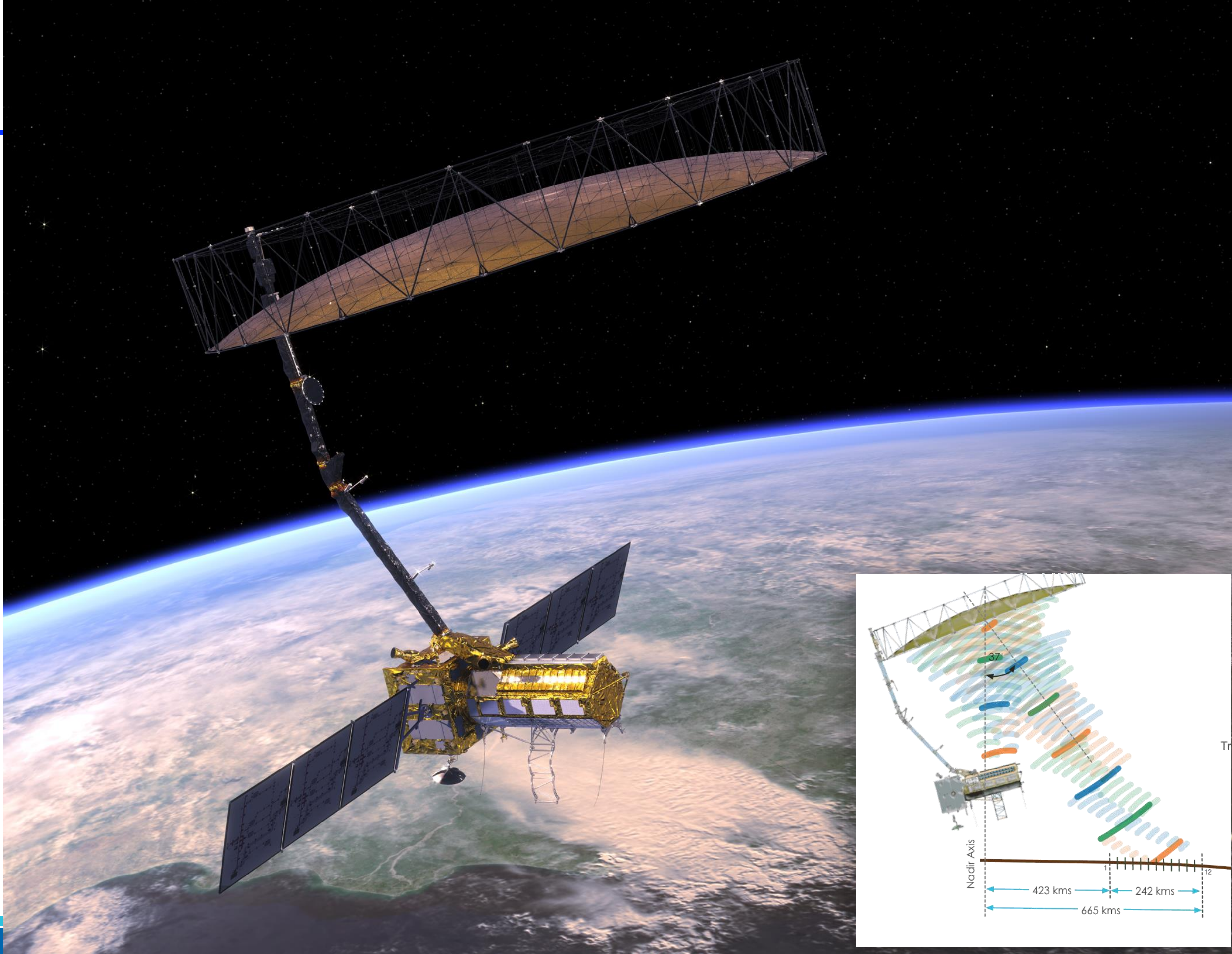
12-day exact repeat for interferometry

On average 6-day coverage with ascending and descending orbits

Near global land and ice coverage on every orbit

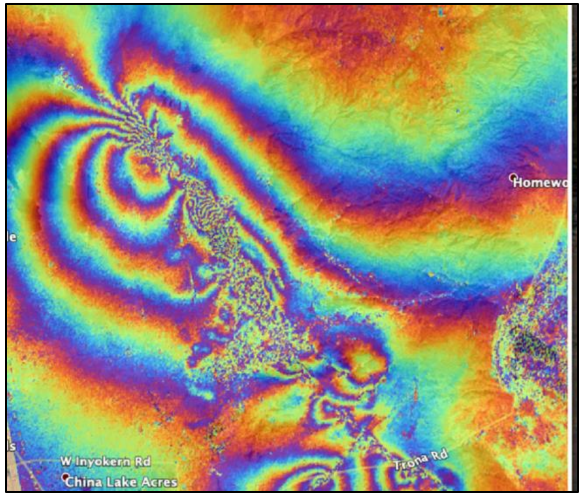
Anticipated Launch date: June 2025

https://science.nasa.gov/blogs/nisar/ for more info



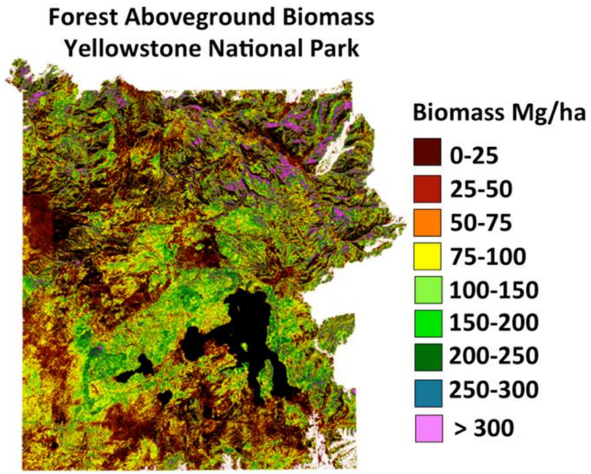
NISAR Level 1 Science and Applications Requirements

Understanding the Cryosphere, Carbon, Catastrophic Change, Resource Management + more



Measure ground movements to understand the forces causing earthquakes, volcanic eruptions, landslides, aquifer and reservoir variations

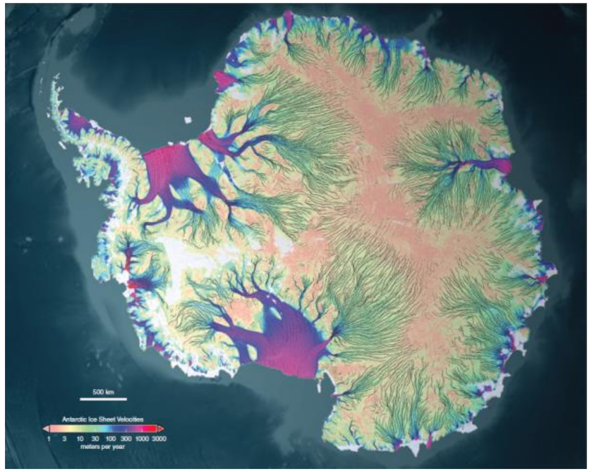
Solid Earth Deformation



Measure the dynamics of global woody aboveground biomass, the dynamics of major wetlands and agricultural systems

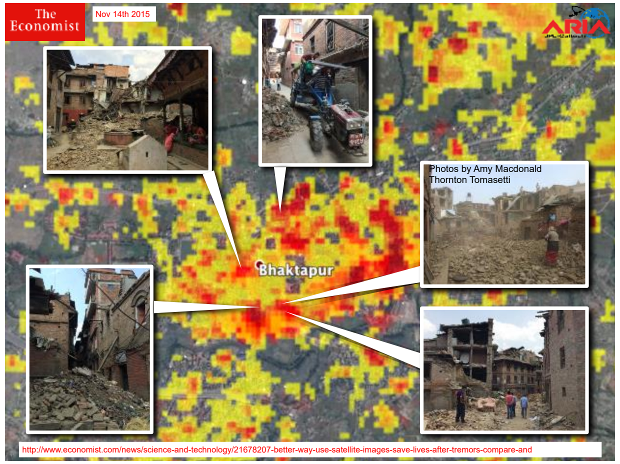
Ecosystem/Agriculture

Cryosphere Dynamics



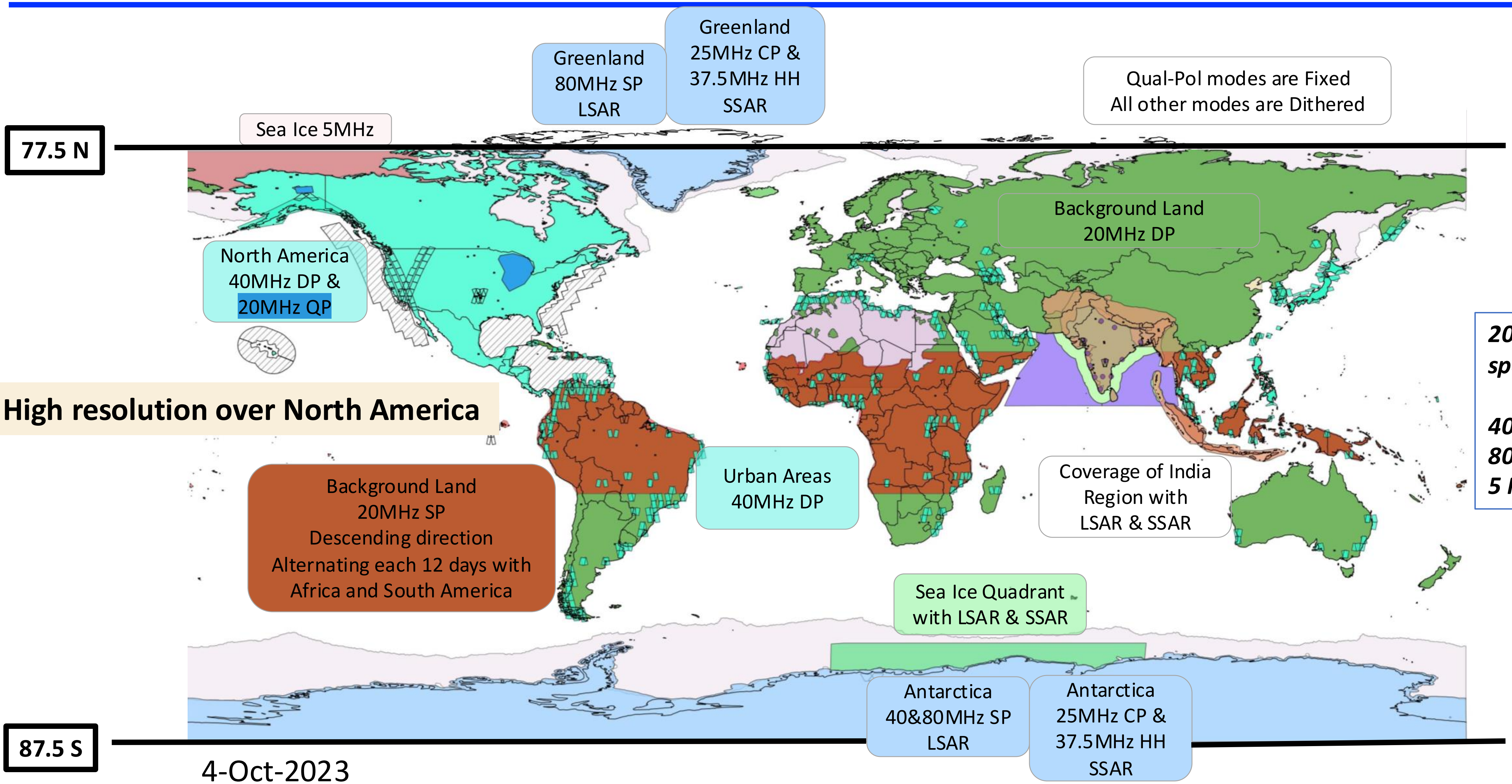
Measure flow of Earth's ice sheets, glaciers, and sea ice to understand their interaction with the oceans, land surface, ecosystems and water

Disaster Response



Provide priority data collection/downlink along with rapid processing and data dissemination for major anthropogenic and natural disasters, on a best-efforts basis

Current Observation Plan Coverage
Plan minor revisions every 6 months



20 MHz = 12 m spatial resolution

40 MHz => 6 m
80 MHz => 3 m
5 MHz => 50 m

4-Oct-2023

Urgent Response Requests

- The science team can make Urgent Response requests through the Smart Tasking Tool
- ST requests will be dispositioned along with other approved requesters
- Most requests will be to accelerate processing timeline by using preliminary orbits and limited ancillary data (e.g. ECMWF model)

- Automated UR requests from 3 US Agencies (US Forestry, USGS VNS, USGS NEIC)
- ISRO uses Smart Tasking Tool Web Interface or API

Example Events

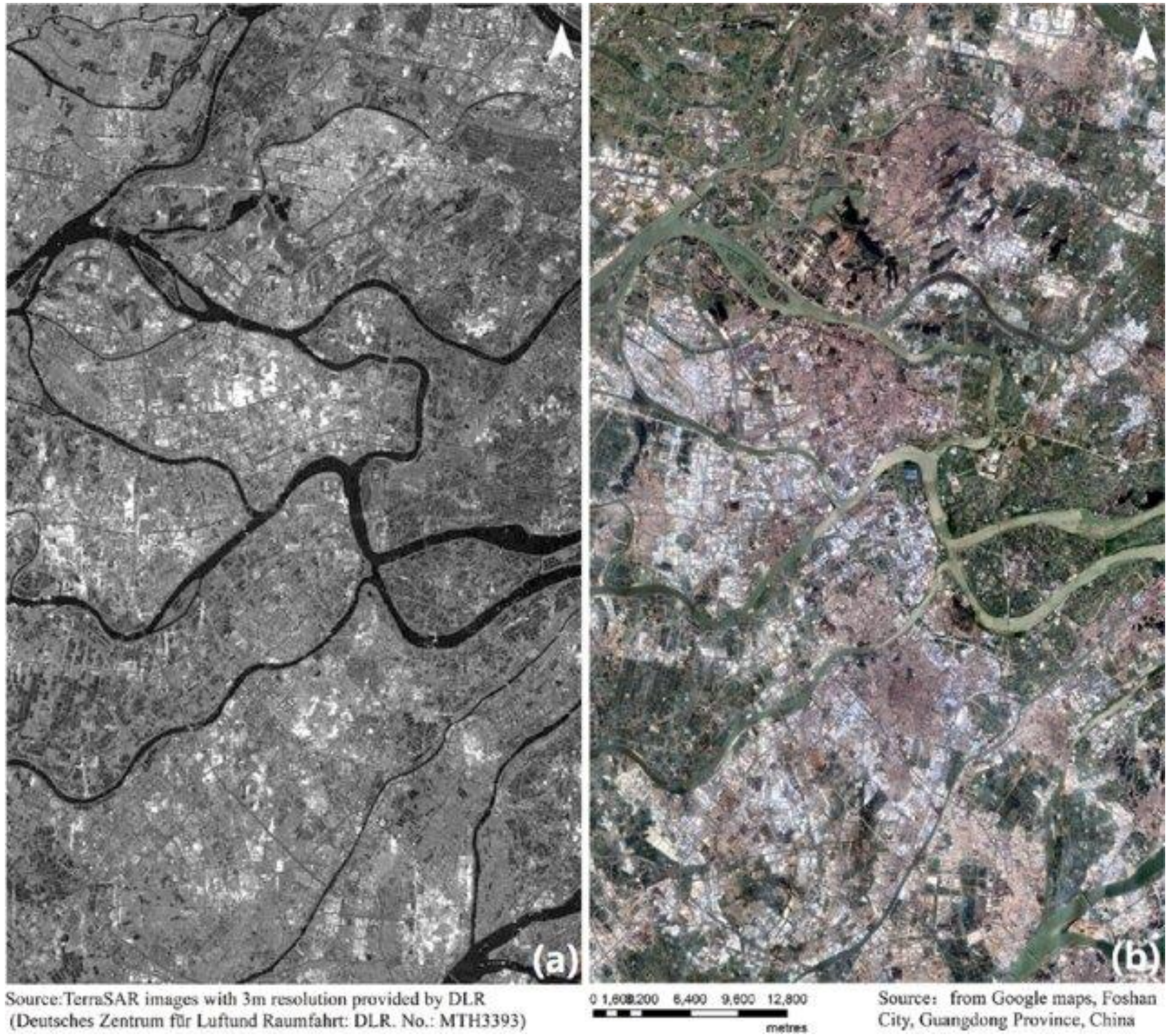
Incoming UR Request

Outgoing Project Response

Request Submitter (Science, ISRO, Event Monitoring Agency) → NISAR Science Data System (Smart Tasking Tool) → NISAR Ground Data System (SmartXfer, Operations Storage Server) → NISAR Ops Team and Mission Planning

Microwave Remote Sensing with Synthetic Aperture Radar (SAR)

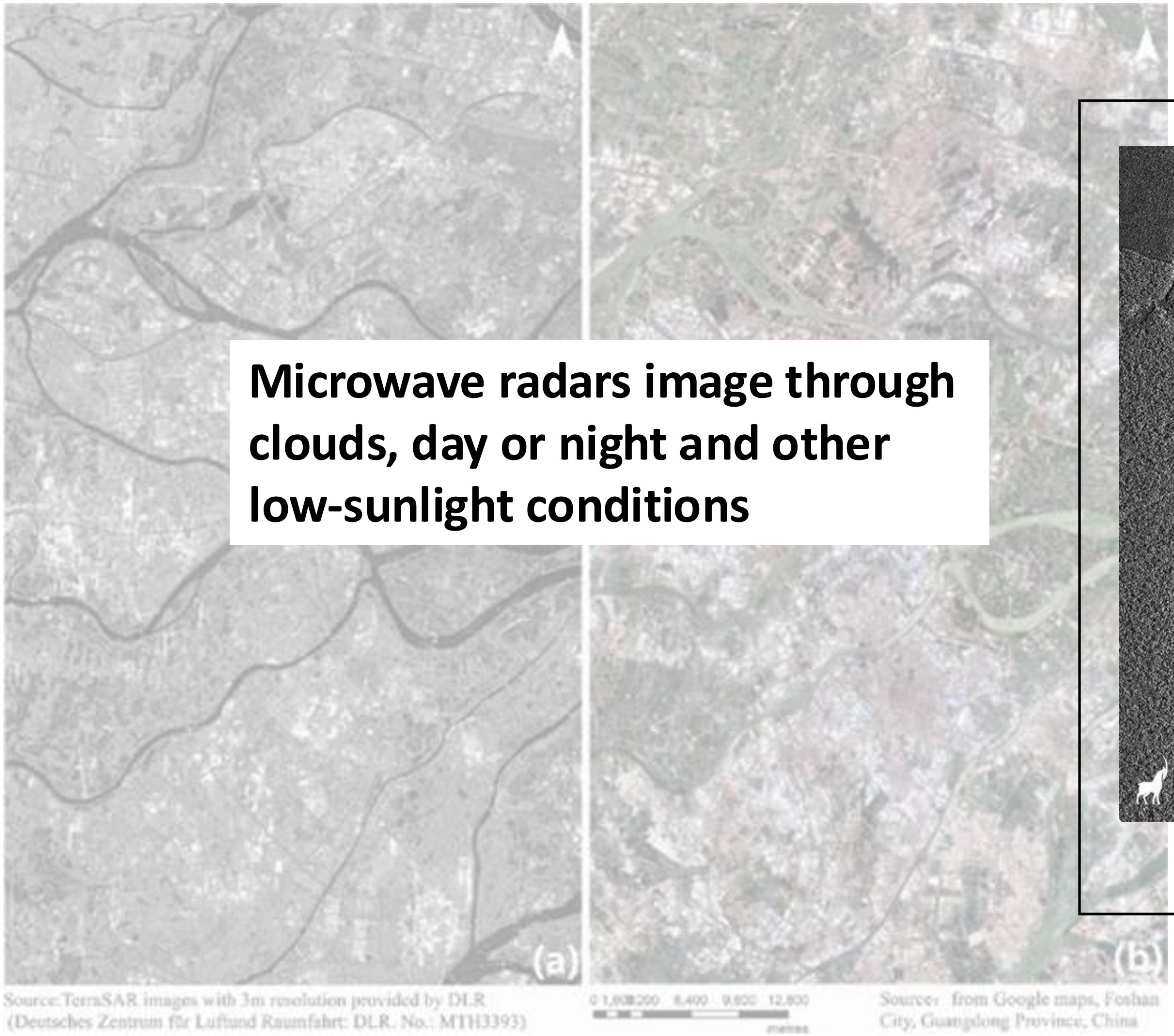
SAR | OPTICAL



Source: Chen IJAEOG 2021 LINK by-nc-nd-4.0

Water is dark in radar images =>
Has good contrast in many settings

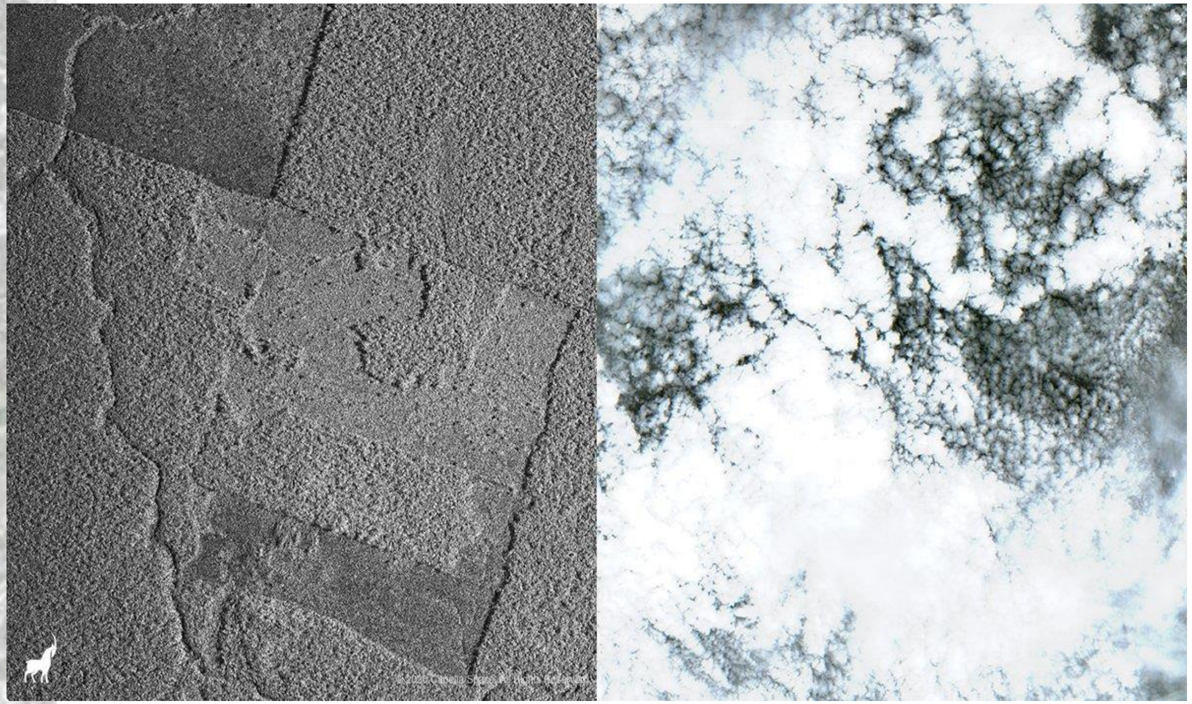
Microwave Remote Sensing with Synthetic Aperture Radar



Microwave radars image through clouds, day or night and other low-sunlight conditions

Source: Chen IJAEOG 2021 LINK by-nc-nd-4.0

SAR OPTICAL

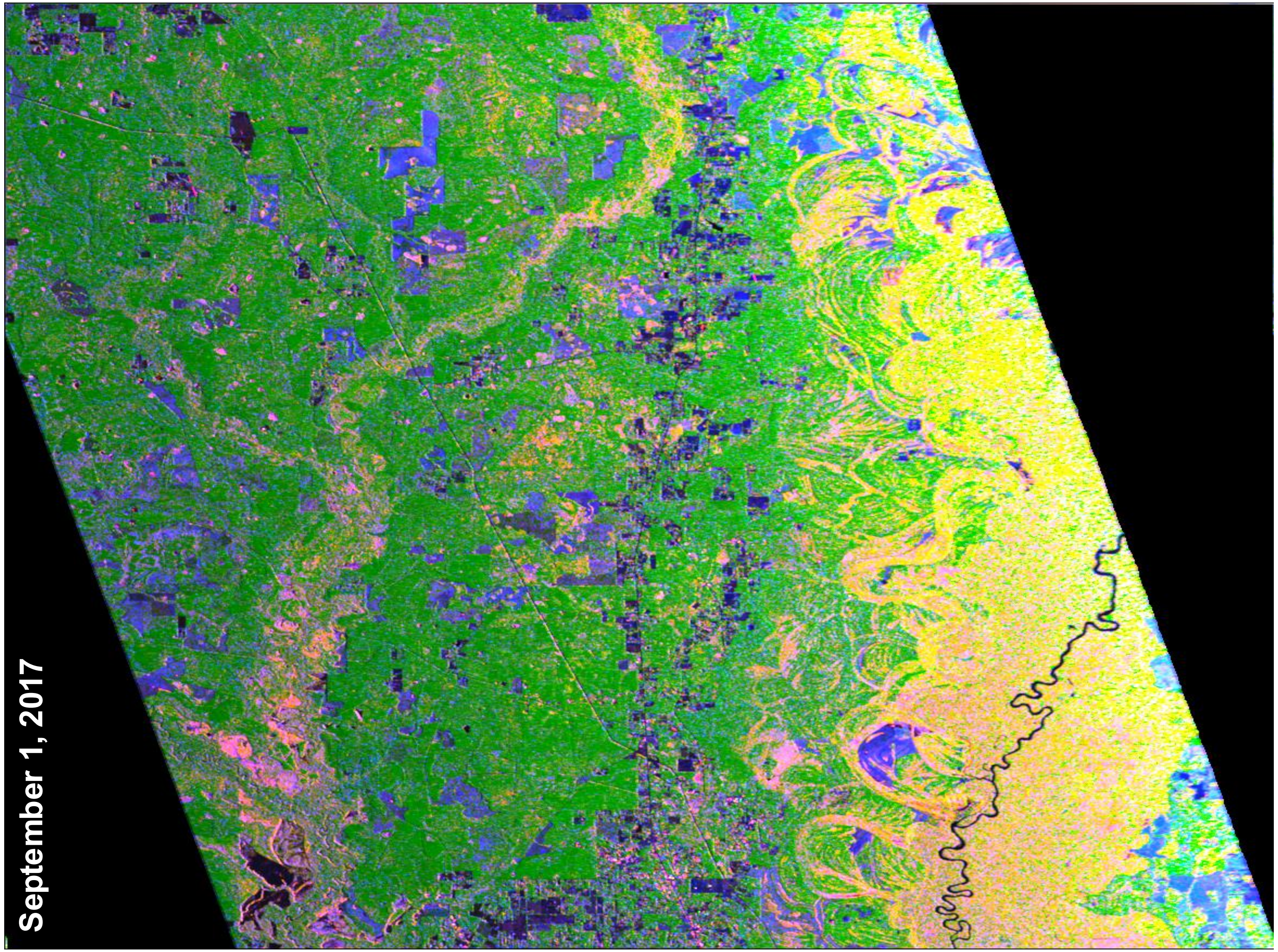


Source: Capella Space LINK

FLOOD DISASTER RESPONSE – Flooding Below Vegetation (PolSAR)

HURRICANE HARVEY, TEXAS, 2017

NECHES RIVER & TRIBUTARY



Scattering Mechanism: Red=Double Bounce, Blue=Single/Odd Bounce, Green=Volume

PURPLE/BLUE = Open water (river or water-covered vegetation)

YELLOW/ORANGE/ PINK = Flooded vegetation (emergent)

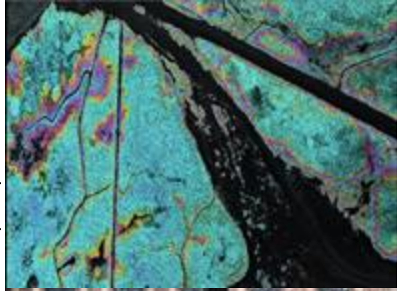
DATA FROM NASA UAVSAR

FLOOD DISASTER RESPONSE – Critical Infrastructure

HURRICANE HARVEY, TEXAS, 2017

OVERTOPPING OF BRIDGE ON LAKE HOUSTON (San Jacinto River)

BRIDGE IS OVERTOPPED HERE

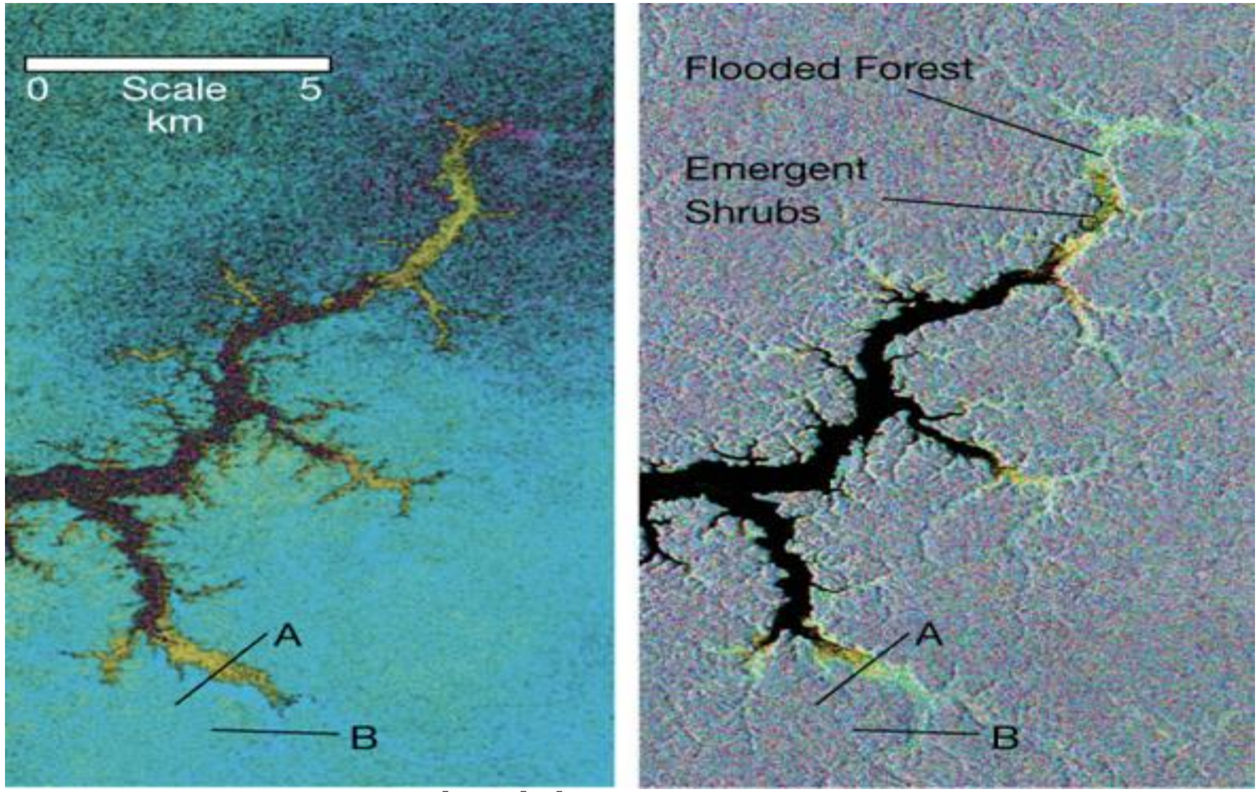


Photos (top-to-bottom): UAVSAR image NASA/JPL, Genaro Servin (Pexels), Pixabay, Pexels (4-5)

Flood Forecasting

Flood forecasting informs downstream communities if a flood is coming and how much flooding to expect. Like a virtual stream gauge, synthetic aperture radar is able to measure changing water levels in standing vegetation as flood waters from heavy upriver rains head downstream.

"Change in water level" products in flooded, vegetated areas were first demonstrated by the NASA SIR-C Synthetic Aperture Radar. In this image, centimeter-level changes in water level were measured over the Purus River in Brazil from two observations acquired 24 hours apart. (Alsdorf et al., Nature, 2000). Colors indicate how much the water level changed between the two observations. Between transects A & B there is 1-5 cm change in water level.



nisar.jpl.nasa.gov

NASA-ISRO Synthetic Aperture Radar (NISAR) Mission

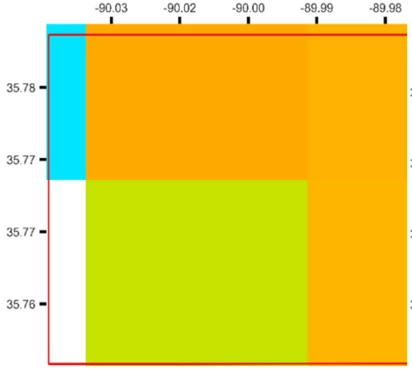
Satellite Needs Working Group NISAR Soil Moisture Product

200m (Global minus Sahara and Antarctica) and 400m Sahara

Product Specifications

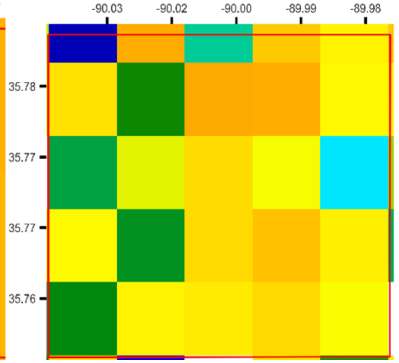
Spatial resolution	200m Near Global, 500 m Sahara
Temporal revisit	Twice every 12-days: 6-day average with ascending & descending
Coverage	Global (higher uncertainty for forest, steep terrain, arctic)
Data access	Amazon cloud through Alaska SAR Facility: free access
Latency	72 hours
Available	90 days after launch (April 2024)
Grid	EASE-II (Equal Area Scalable Earth)
Accuracy goal	6 levels of wetness, 0.06 m3/m3 unbiased rmse

Current Satellites



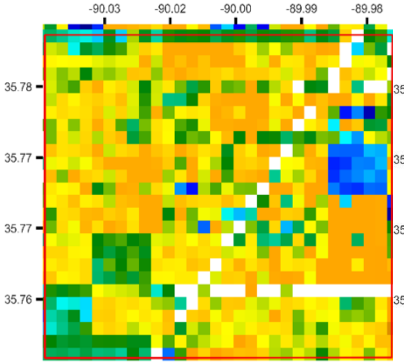
Resolution: 3 km

Infrequent/Regional



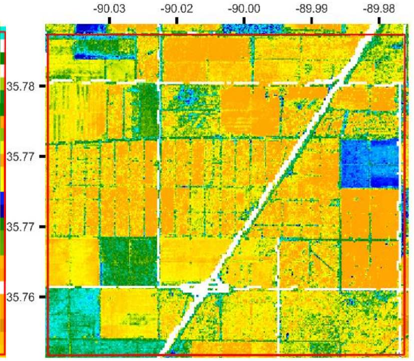
1 km

SNWG-NISAR



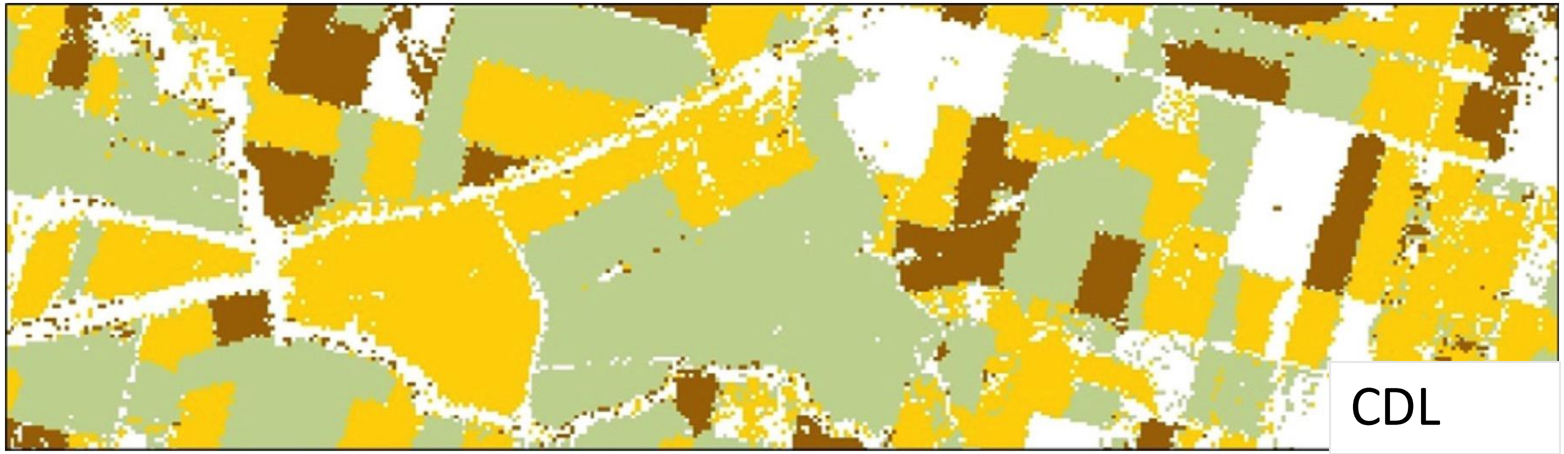
200 m

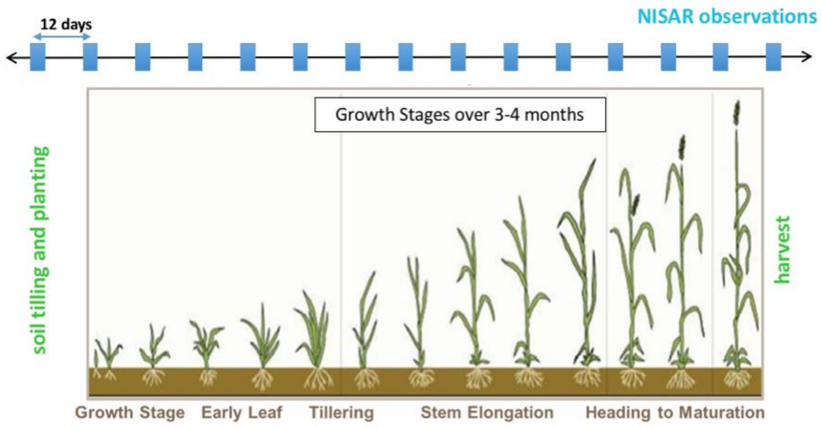
Airborne

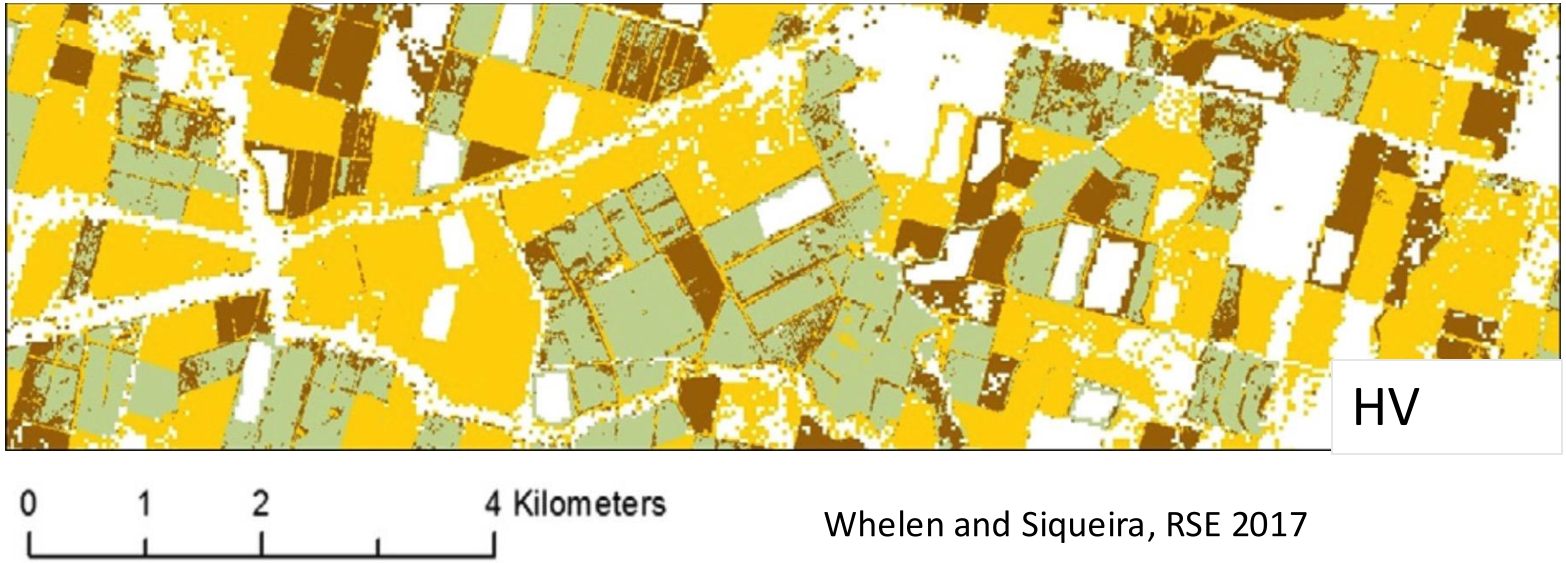


18 m (domain 5 x 5 km)
[Ponnu Ganesan]

Polarized SAR time-series data enables the tracking of crop type growth throughout the growing season







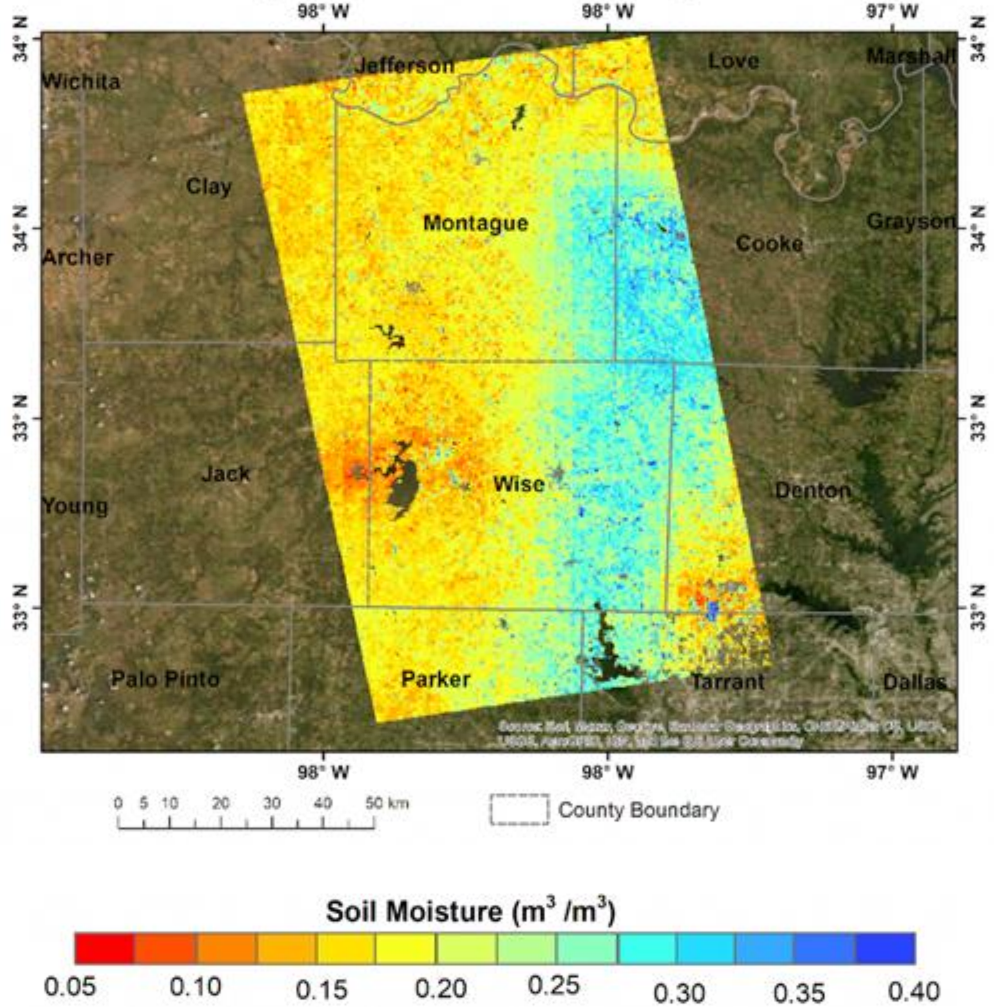
Whelen and Siqueira, RSE 2017

CDL = Crop Data layer
HV = Polarized SAR data, Horizontal transmitted Vertically received

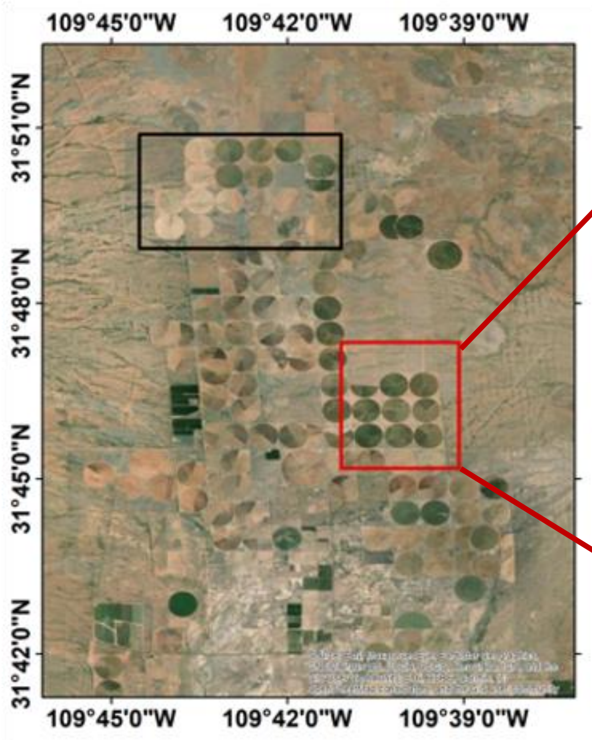
NISAR's Will Generate Global 200m Soil Moisture Maps

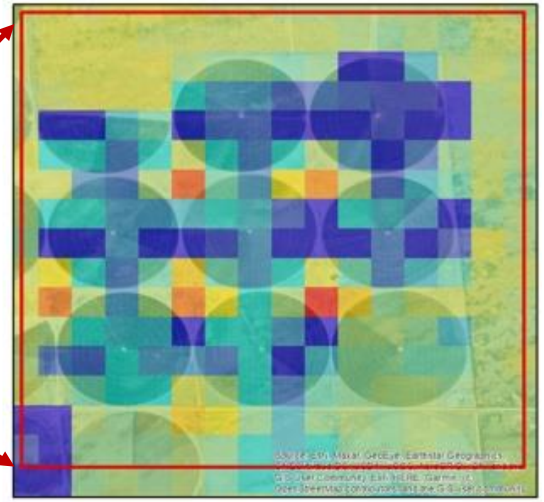
Near Global Coverage Twice Every 12 days, Sahara 400m Product

Simulated global NISAR 200-meter soil moisture over cropland in Texas on Sep 19, 2022



NISAR will generate field-scale soil moisture products





Irrigated in Arizona (10kmx 5km)

- NISAR's global soil moisture will provide detailed information for farmers, land managers, and forecasters
- The products will help understand pre-disaster conditions (i.e. fires, floods) and drought onset

Snow Hydrology

Photos: (bottom to top) Alexandra Giese; USGS; Alexandra Giese; USGS; USGS/Benjamin Oppenheimer

Glaciers and snow in mountain regions are changing drastically in the 21st century. Earth observations are crucial for quantifying how these changes impact water resources, sea level rise, and river ecosystems. NISAR can provide information about snow conditions and measure the flow of mountain glaciers over time, helping us better understand the scope and impact of change.

The sequence of maps shows the seasonal snow melt progression in the Upper indus Basin, during the period from April to July for a glacierized basin (200 x 100 km) derived from the Sentinel-1 C-band radar. The snow and ice facies progress from dry snow, to snow that is melting during the day and refreezing at night, to consistently wet snow.

Lund et al., 2020

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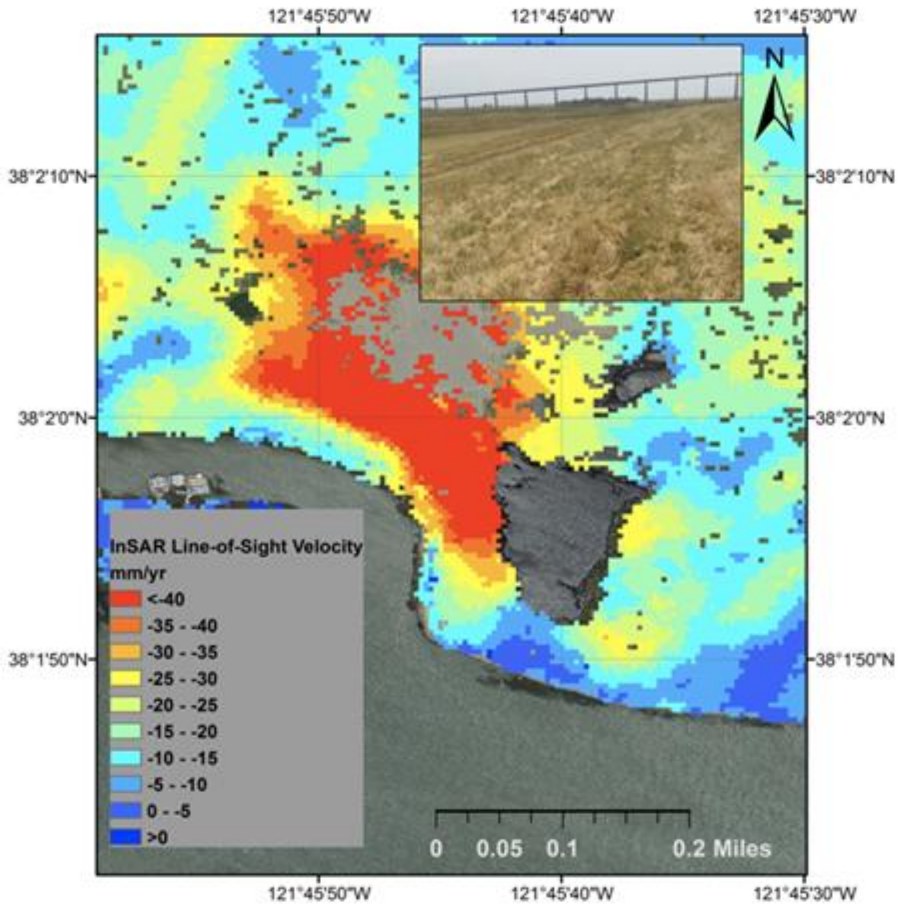
Photos (top-to-bottom): NOAA, Texas A&M Forest Service, NOAA, FEMA, Tom Fisk (Pexels)

Levees and Dams

A vast network of dams and levees protect communities throughout the U.S. from floods. Maintaining these structures is absolutely critical and requires constant vigilance. Radar remote sensing with NISAR can provide early warning of movement and seepage in time to prevent disaster.



Map showing rate of ground movement along one of the levees that prevents flooding of an island in the Sacramento-San Joaquin Delta [Deverel et al., 2016]. The inset photo shows a view looking east towards the area of most rapid movement.

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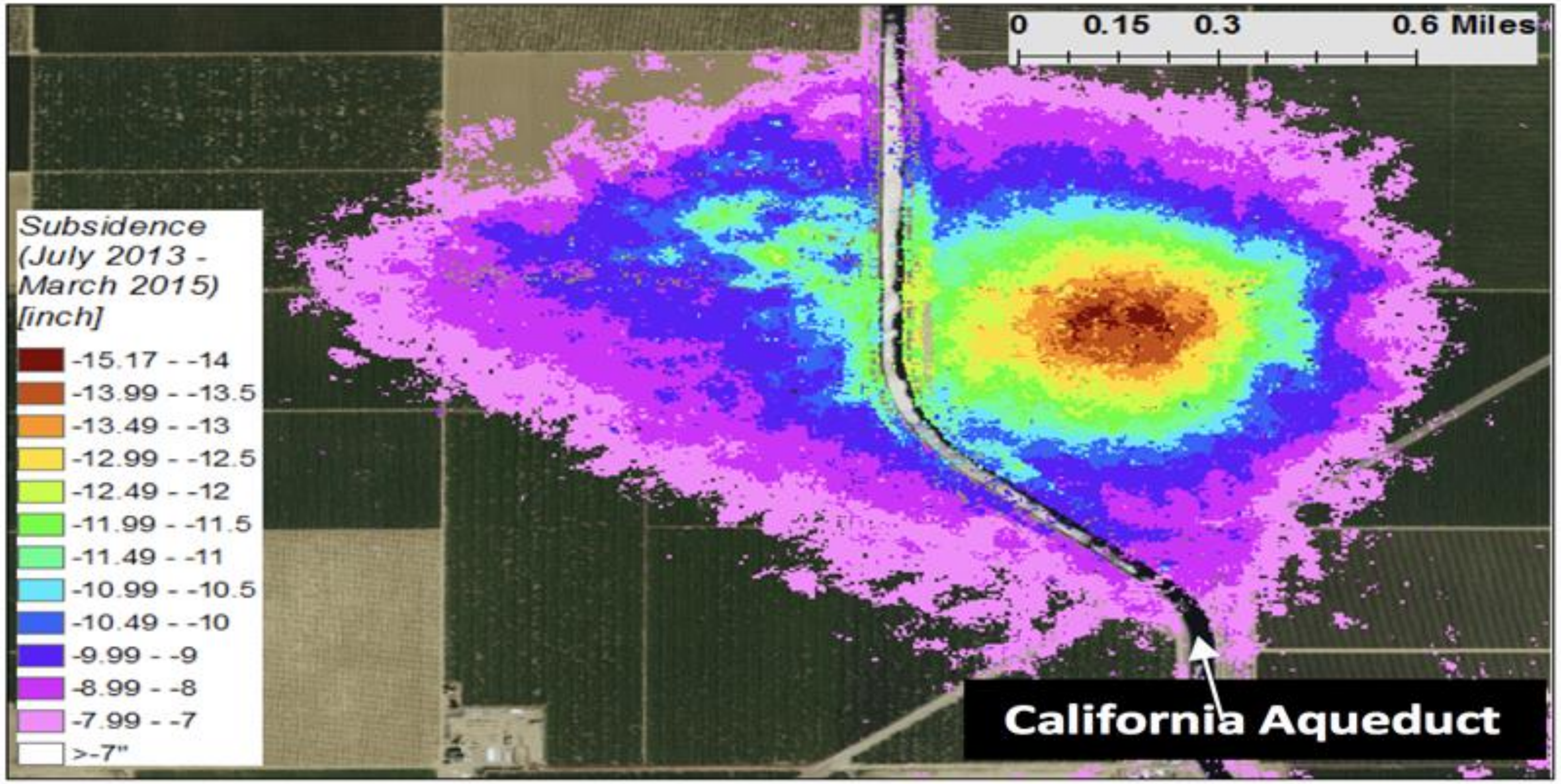
nisar.jpl.nasa.gov

Drought and the Rapidly Changing Landscape

Photos (top-to-bottom): Ca. Dept. of Water Resources, Ca. Dept. of Water Resources, USGS, Va. Water

Droughts are accompanied by a host of troubles. The reduced surface water capture and supply results in more groundwater withdrawal, which in turn leads to ground subsidence that can impact infrastructure and even exacerbate future flooding in the very areas hardest hit by the drought.

SAR-derived map of ground subsidence in the Central Valley, California, associated with groundwater pumping [Farr et al., 2015].



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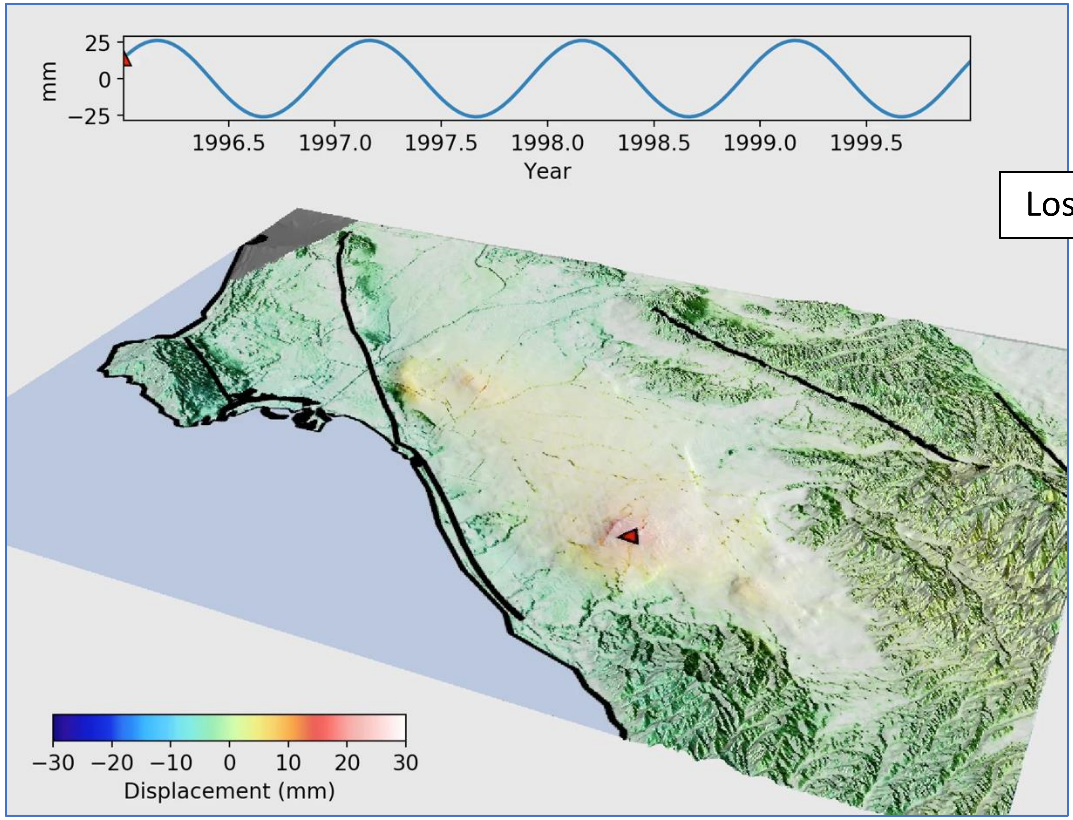
NISAR Will Systematically Measure Land Motion Globally Twice Every 12 Days

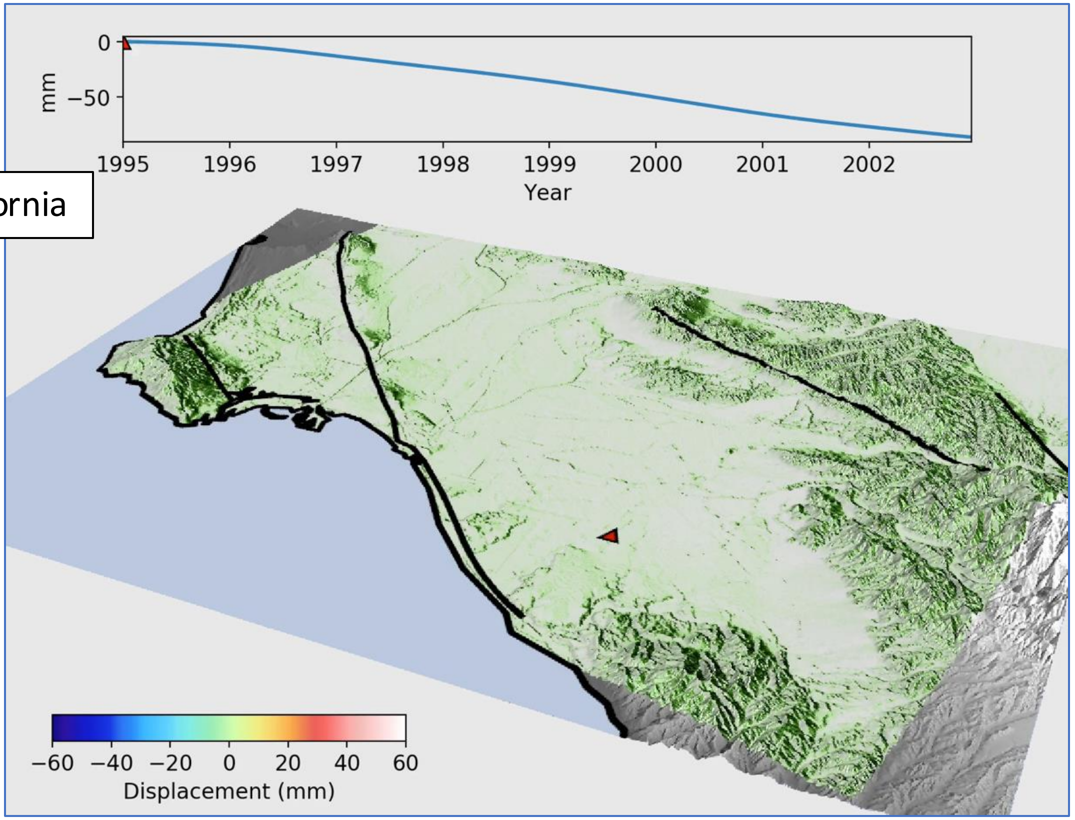
Groundwater Pumping Induced Seasonal and Annual Land Surface Deformation

Seasonal uplift and subsidence of 50 mm (2 in) every year associated with groundwater management



Los Angeles, California

Ongoing groundwater pumping resulted in 10 cm (~4 in) of land subsidence in less than a decade across Greater Los Angeles



Aquifers are recharged from surface water year-round, and are pumped May to September every year

Continued groundwater pumping results in annual subsidence and the compaction of aquifer layers

Data: 18-year time series (881 InSAR interferograms) + GPS sites

Credit: M. Simons, B. Riel (Caltech)

Open-Source Science for NISAR

- Open data – per NASA data policy – at the Alaska Satellite Facility DAAC
  - NISAR Sample Data Product Suite: https://nisar.jpl.nasa.gov/data/sample-data/
  - Pre-launch Sample products: https://uavsar.jpl.nasa.gov/science/documents/nisar-sample-products.html
  - Post-launch Science products
  - *NISAR will be two times larger than the current EODIS Archive.*
- Open Source Software – SDS and data processing code available for download
  - InSAR Scientific Computing Environment, Enhanced Edition (ISCE3): https://github.com/isce-framework/isce3
- Open Source Science algorithms for science products
  - Jupyter notebooks available for download: https://gitlab.com/nisar-science-algorithms
- Open Source Training Opportunities
  - Jupyter notebooks in cloud training environments at Alaska Satellite Facility OpenScienceLab
  - ARSET and other courses: https://nisar.jpl.nasa.gov/resources/sar-education-resources/
- Free cloud computing resources for NASA subscribers

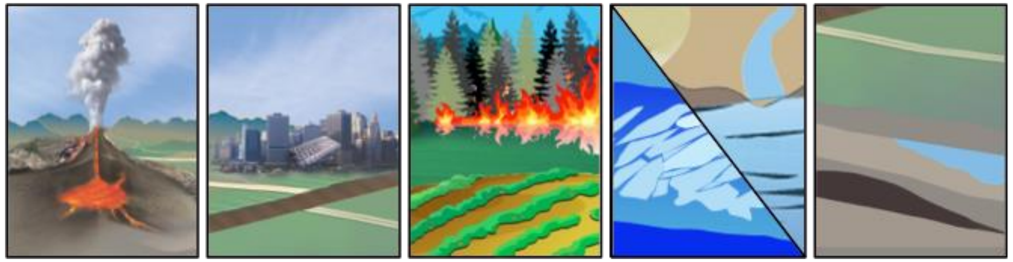
NISAR Applications Program

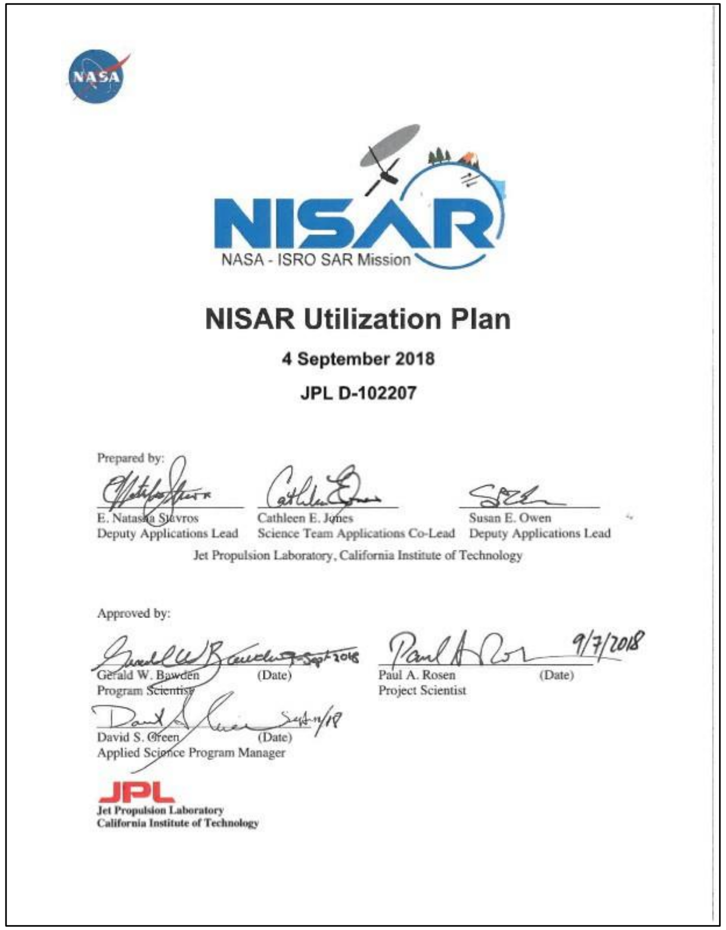
Community Engagement

1. NISAR Applications Workshops
    - 2014-2016 Omnibus Applications Workshops
    - 2017-2023 Focused Area Applications Workshops
2. Training & Engagement
3. Early Adopters' Program
4. User Community Envoys

Disaster Response

1. Urgent Response Working Groups
    - Plan and prepare for disaster response





NISAR
NASA - ISRO SAR Mission

NISAR Utilization Plan

4 September 2018

JPL D-102207

Prepared by:

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Paul A. Rosen 9/7/2018 (Date), Project Scientist
David S. Green (Date), Applied Science Program Manager

JPL
Jet Propulsion Laboratory
California Institute of Technology

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

NISAR Community Meetings and Workshops

2014 NISAR Applications
2015 NISAR Applications
2015 ISRO Utilization
2016 Vegetation Biomass
2017 Critical Infrastructure
2017 Sea Ice
2018 Forest & Disturbance
2018 Agriculture and Soil Moisture
2018 Wetlands
2019 Landslides
2019 Volcanos
2020 Induced Seismicity
2022 Land Subsidence
2022 Science Community
2023 ISRO Community
2023 Environmental Justice
2023 Extreme Weather
2024 ISRO Community (TBC)

Pasadena, CA 2022

Ahmedabad, India 2023

Alaska Satellite Facility Trainings

Agenda example for Early Adopters

<u>Day 1</u>

- Intro to the workshop
- Intro to ASF and SAR
- Intro to NISAR products (including sample products)
- Intro to OPERA products, including NISAR products with timelines & coverage
- Set up environment/s (git, conda)
- Break
- Accessing data with Vertex and Hyp3
- Tutorial Snow Moisture
- Tutorial Coefficient of Variation
- Q&A
- Wrap up

<u>Day 2</u>

- Intro to day 2 of the workshop
- Intro to working with NISAR data
    - Working with data in HDF5
        - Python
        - HDFView
        - QGIS
- NISAR sample data
- Intro to SBAS time series analysis
- Tutorial MintPy using ARIA S1 GUNW
    - ARIA-tools and Mintpy processing of S1 stacks
- Tutorial or presentation subsetting
- Break
- Tutorial or presentation permafrost InSAR with HyP3 gamma stack
- Point to HyP3 on-demand Mintpy recordings
    - Add to Jupyter Book
- Q&A
- Wrap up

Resources: Application White Papers

NISAR: The NASA-ISRO SAR Mission

National Aeronautics and Space Administration

Earthquake! Tracking Location and Impact from Space

Earthquakes occur suddenly, often with intense ground shaking that causes loss of life and property. They and their aftershocks can induce landslides, lead to fires, and even bring neighboring faults closer to rupture. NISAR will provide measurements of ground deformation along faults before an earthquake occurs, from the earthquake itself, and in the time following, all key information for understanding where and why earthquakes occur.

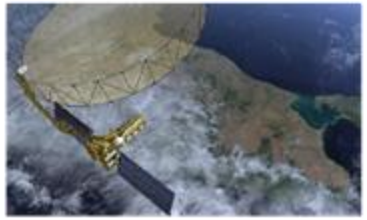
Earthquake Hazards in the United States and Around the World

Earthquakes in the United States are estimated to cost about \$5.3B annually (FEMA, 2008). Earthquakes can damage buildings and critical infrastructure, rupture gas and water lines, cause landslides, and create liquefaction. Sedimentary basins can amplify earthquake shaking, even for distant earthquakes. The 1985 Mexico City earthquake occurred 350 km from the city, but because the city is located on an ancient lakebed, it experienced intense shaking, killing thousands of people. Subduction zone earthquakes that originate offshore can create tsunamis, resulting in further damage and loss of life. The 2011 M9.0 Tōhoku-oki earthquake offshore of Japan created tsunami waves reaching as much as 130' high. Landslides and fires are additional hazards that cascade from earthquakes. Fires broke out after the 1906 M7.9 San Francisco earthquake destroying much of the city.

Photos: USGS

Plate Tectonics and Earthquakes

Movement of Earth's tectonic plates causes strain to accumulate in the crust, which eventually drives fault to rupture. Following major earthquakes, the ground continues to deform and aftershocks occur as the crust responds to the changes in stress. Surface motion in the area around an earthquake fault are measurable throughout this entire earthquake cycle of loading, rupture, and recovery.



The NISAR Mission – Reliable, Consistent Observations

The NASA–ISRO Synthetic Aperture Radar (NISAR) mission, a collaboration between the National Aeronautics and Space Administration (NASA) and the Indian Space Research Organization (ISRO), will provide all-weather, day/night imaging of nearly the entire land and ice masses of the Earth repeated 4-6 times per month. NISAR's orbiting radars will image at resolutions of 5-10 meters to identify and track subtle movement of the Earth's land and its sea ice, and even provide information about what is happening below the surface. Its repeated set of high-resolution images can inform resource management and be used to detect small-scale changes before they are visible to the eye. Products are expected to be available 1-2 days after observation, and within hours in response to disasters, providing actionable, timely data for many applications.

National Aeronautics and Space Administration

Cont. from front page

Earthquakes can occur in many parts of the world, but nearly 90% happen along the Ring of Fire, the area around the rim of the Pacific Ocean where most active volcanos lie. The Ring of Fire includes Japan and California, both parts of the world where earthquakes are frequent occurrences.

When an earthquake fault ruptures, seismic waves radiate away from the fault causing ground shaking along their path. It is common for this seismic shaking to trigger landslides and to indirectly induce fires. Understanding the likely scale and location of future large earthquakes is therefore an important ingredient in preparing for them and reducing the loss of life and property.

Faults generally slip continuously deep within the Earth, but near the surface the faults can be 'locked' or 'clamped,' and do not move continuously. These shallower locked portions are the source of the earthquakes we feel. The deep fault slip manifests at the surface as small shifts in the ground, or deformation, that is localized around the faults. Detection of areas with higher rates of deformation can be used to identify active faults. The rate of slip across the fault, depth at which the fault becomes locked, and the length of the rupture all contribute to the magnitude of an earthquake, with larger slip and longer ruptures resulting in more powerful earthquakes. Therefore, determining long-term slip rates on faults and other characteristics is key to forecasting earthquake hazard.

Earthquakes are usually the result of tectonic processes; however, they can also be induced by human activity. Such 'induced' seismicity can be the result of geothermal operations, hydraulic fracturing to extract oil and gas, injection of wastewater, and large changes in the stored water at water reservoirs, particularly from water in dams.

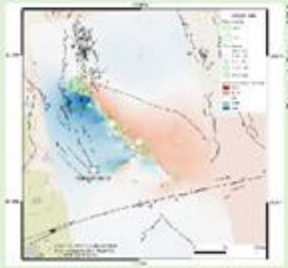
The larger induced earthquakes are typically associated with injection of wastewater used to aid the extraction of oil and gas from underground reservoirs. The injection of water increases pore pressure in the rock and can interact with an existing fault, triggering an earthquake. The injection of fluids can cause measurable uplift or subsidence of the ground surface.

Deformation measured with NISAR will help in mapping fault zones and fault systems around the world and detecting subsidence and uplift associated with human activity. This information is obtained before an earthquake happens and provides insight into how they will behave. Following earthquakes, NISAR will identify earthquake ruptures and measure the amount that the ground slipped along the faults, mapping the length of the rupture and providing an indication of damage extent. NISAR will be used to locate areas of damage to roads, buildings, and other structures, and provide information about other disasters triggered by the earthquake

Earthquake fault motion and damage

In 2019 two earthquakes occurred near the town of Ridgecrest and the China Lake Navy facility in southern California. A M6.4 earthquake on July 4, 2019 was followed by a M7.1 earthquake on July 5, 2019 about 34 hours later. The two faults ruptured nearly perpendicular to each other. Radar can be used to measure permanent ground displacements associated with earthquakes as well as continued motions as faults continue to slip aseismically after large earthquakes. Surface disruption can also be measured with radar providing a proxy of where specifically damage occurs to buildings.

The image at right shows the ground displacements from the 2019 Ridgecrest earthquake sequence. Motions can be detected in an area about 60 km long and 40 km wide.

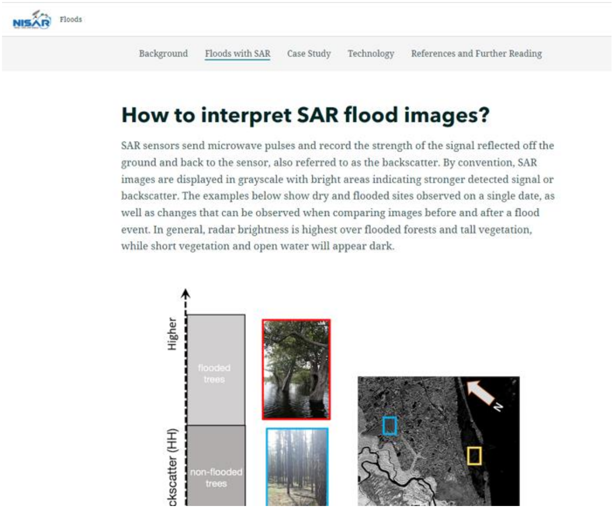


Radar-derived map of ground movement near Ridgecrest, California, following magnitude 6.4 and 7.1 earthquakes in July 2019. Areas west of the main fault rupture (blue) moved northwest while areas east of the fault (red) moved southeast. Black lines show mapped faults.

National Aeronautics and Space Administration **For more information, visit http://nisar.jpl.nasa.gov/applications**

Jet Propulsion laboratory / California Institute of Technology / Pasadena, California / **www.jpl.nasa.gov**

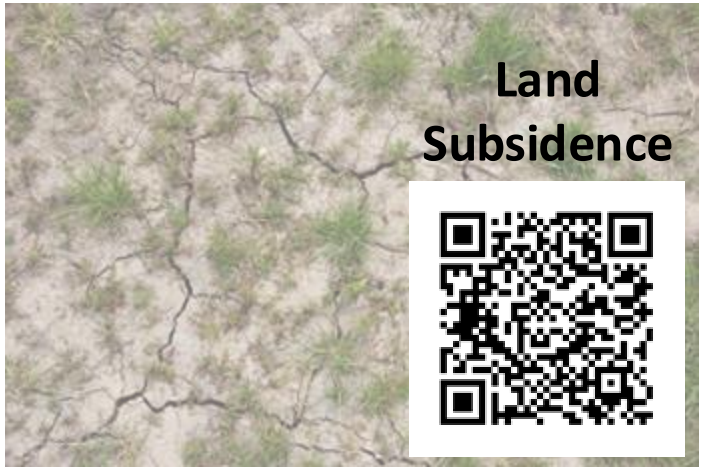
NISAR Applications ArcGIS StoryMaps


Floods

Background Floods with SAR Case Study Technology References and Further Reading

How to interpret SAR flood images?

SAR sensors send microwave pulses and record the strength of the signal reflected off the ground and back to the sensor, also referred to as the backscatter. By convention, SAR images are displayed in grayscale with bright areas indicating stronger detected signal or backscatter. The examples below show dry and flooded sites observed on a single date, as well as changes that can be observed when comparing images before and after a flood event. In general, radar brightness is highest over flooded forests and tall vegetation, while short vegetation and open water will appear dark.



Authors: Annie Peacock, Naiara Pinto, Karen An, Yunling Lou (JPL)

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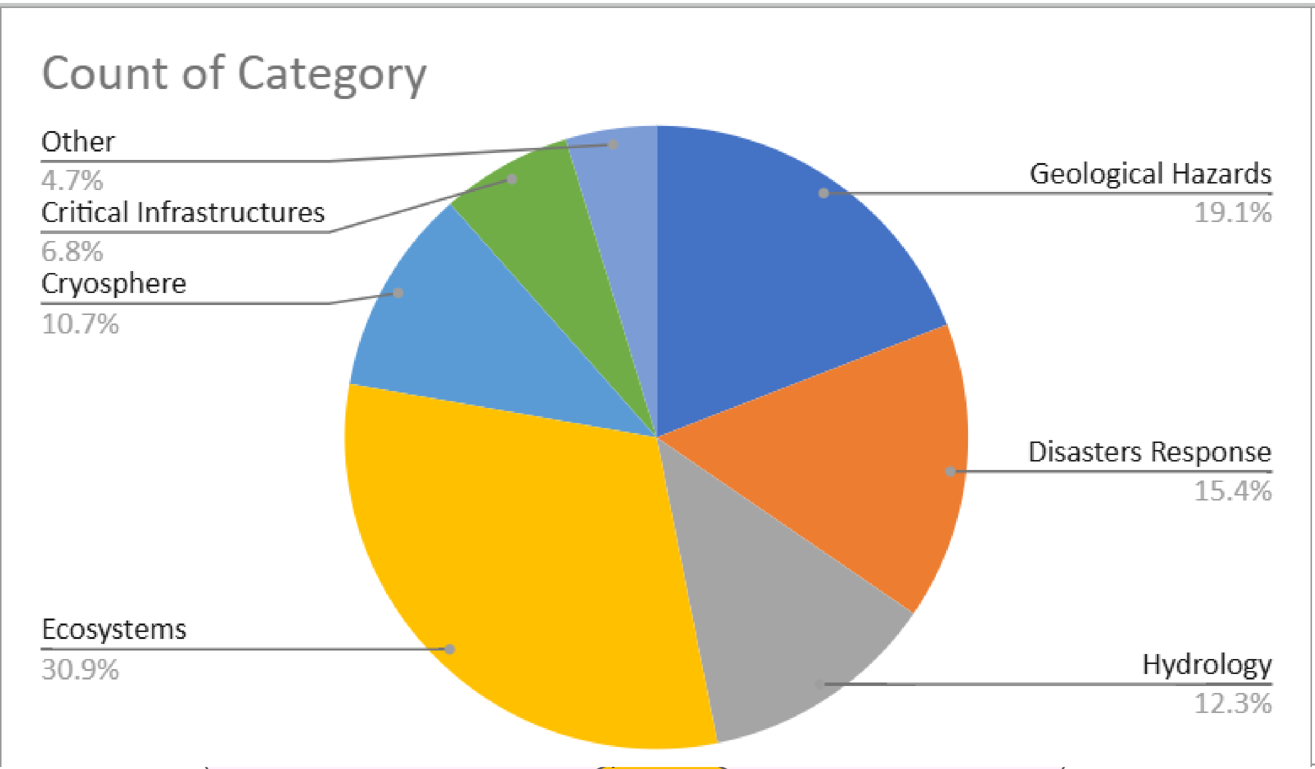
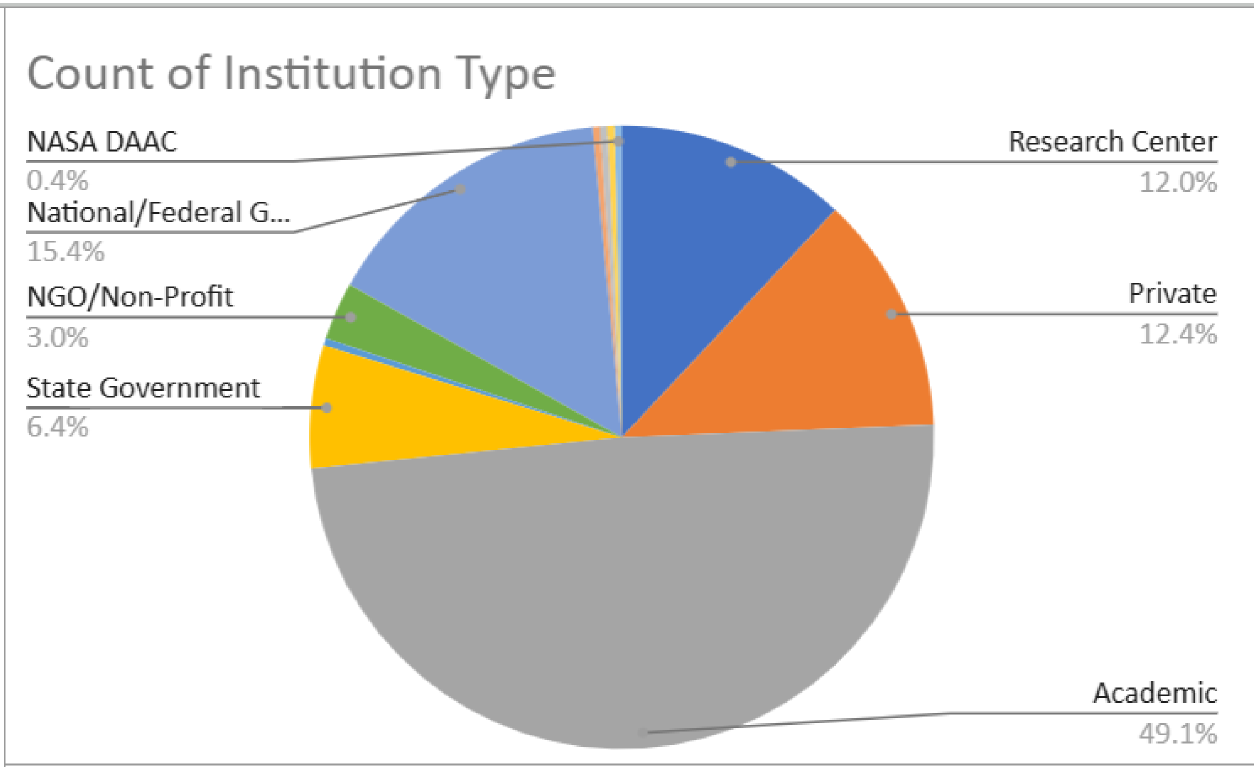
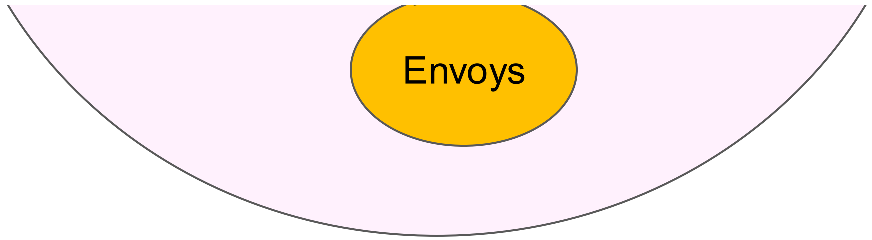
NISAR Applications Community







Community of Practice	Early Adopters	Envoys
461	279	18

*NISAR Mailing List: 1484 members

Early Adopters and Community of Practice

Community of Practice

are individuals or organizations that can be public or private, Federal or local entities, and can have a local, national or international scope for their application.

Early Adopters

are individuals and organizations who

- have a clearly defined need for NISAR data
- have an existing application that can benefit from NISAR and
- are capable of applying their own resources to demonstrate the utility of NISAR data for their application.

Early Adopters provide important feedback to the NISAR team regarding which NISAR data products meet the needs of their applications.

Become and Early Adopter

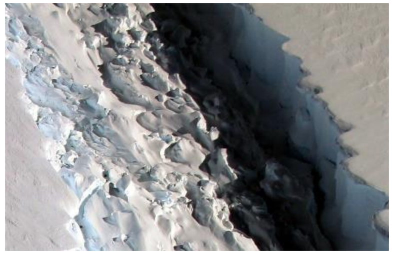
to learn about the NISAR mission and its data, and to join quarterly telecons to present your work, receive feedback and discover opportunities for collaboration!

Apply Here!

https://nisar.jpl.nasa.gov/engagement/application-sign-up

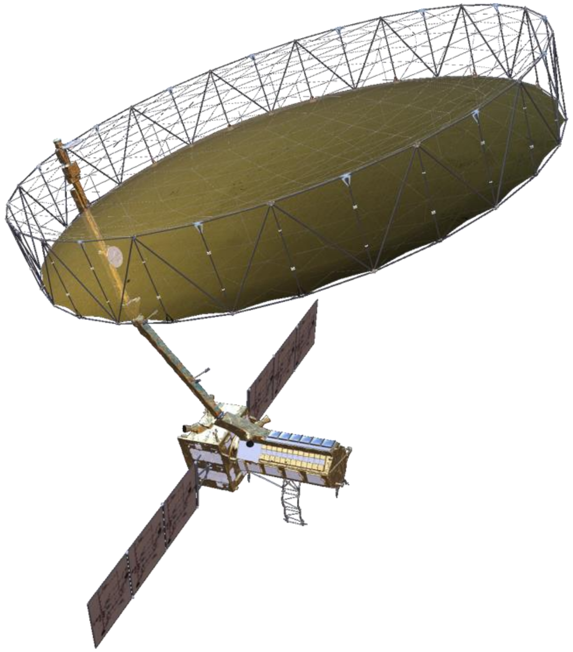
Apply Here!

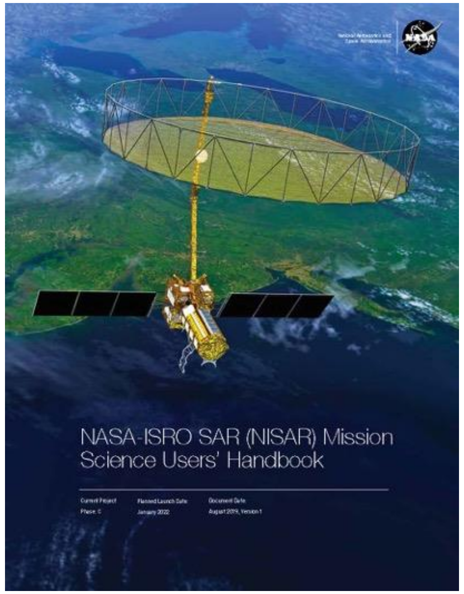





Thank You!

karen.an@jpl.nasa.gov





Join our community!

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OPERA Products based on NISAR

Near Global Dynamic Surface Water Extent - Distributed by PO.DAAC
– Product from Harmonized Landsat 8 and Sentinel-2A/B (HLS) optical data
– Product from Sentinel-1A/B C-band radar data
– Product from ***NISAR L-band radar data***
– Product from SWOT Ka-band radar data

Near Global Land Disturbance - Distributed by LP DAAC
– Product from Harmonized Landsat 8/9 and Sentinel-2A/B (HLS) optical data
– Product from Sentinel-1 C-band radar data

North America Surface Displacement - Distributed by ASF DAAC
– Geocoded line-of-sight displacement products from Sentinel-1 A/B and ***NISAR***
– Geocoded vertical (and horizontal) displacement products from Sentinel-1 A/B

Intermediate Products - Distributed by ASF DAAC
– Radiometric Terrain Corrected Radar Backscatter products from Sentinel-1 A/B
– Coregistered Single Look Complex stack products from Sentinel-1 A/B and ***NISAR***

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