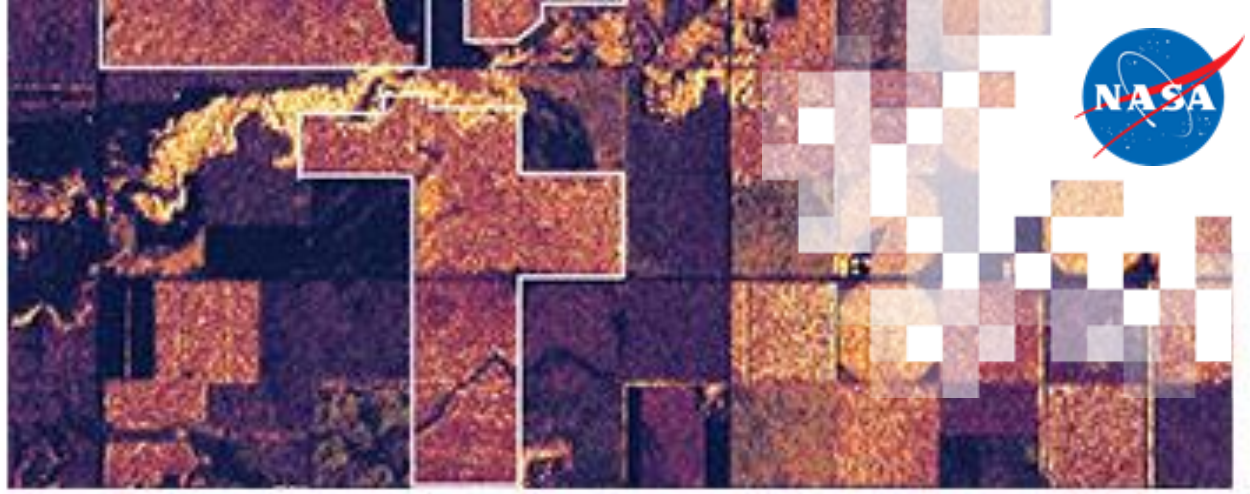
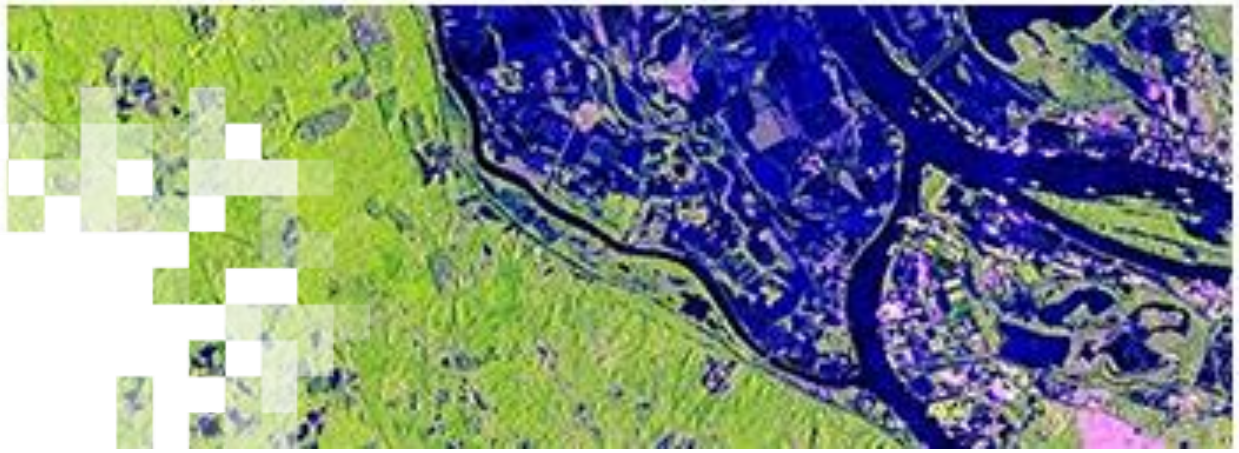
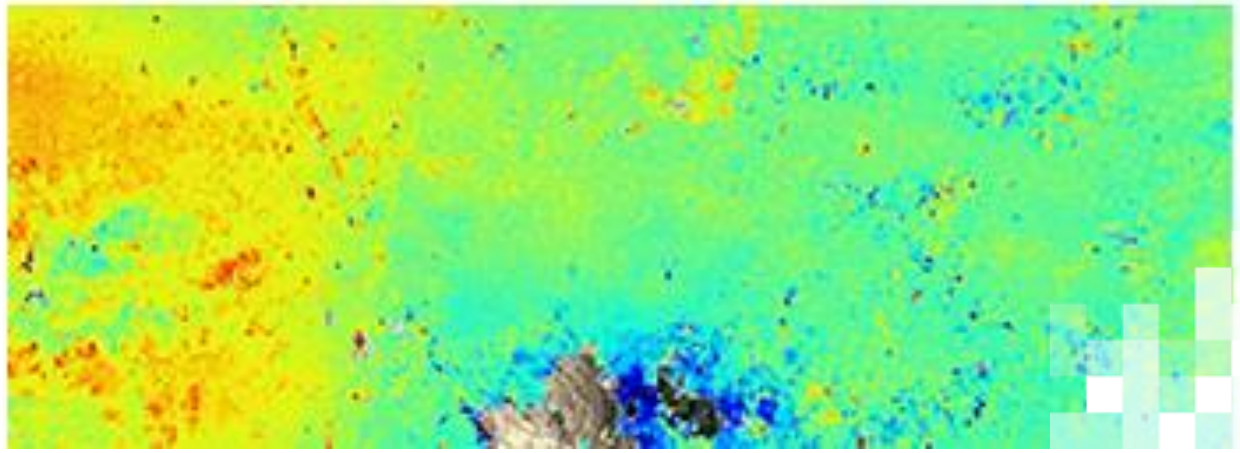




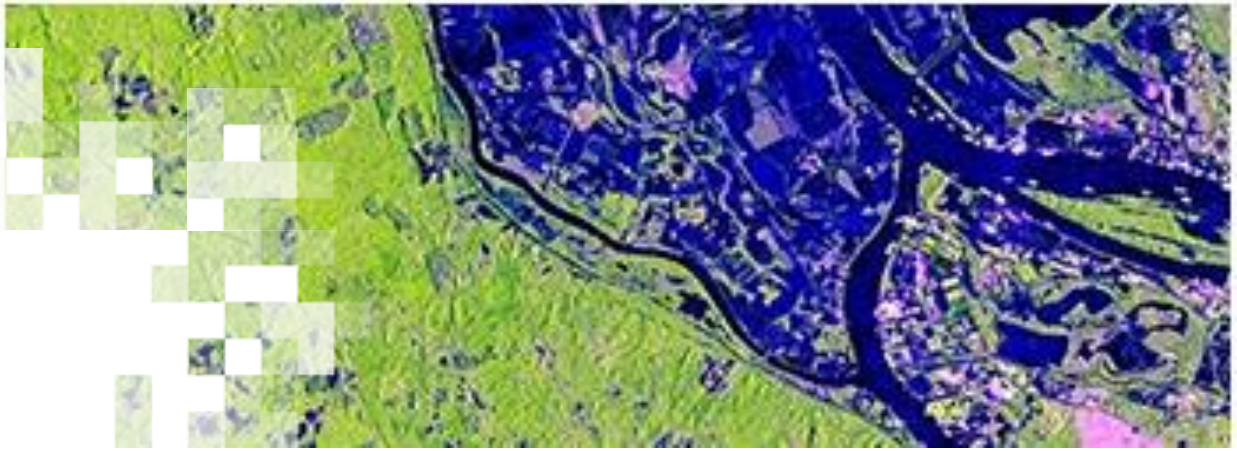


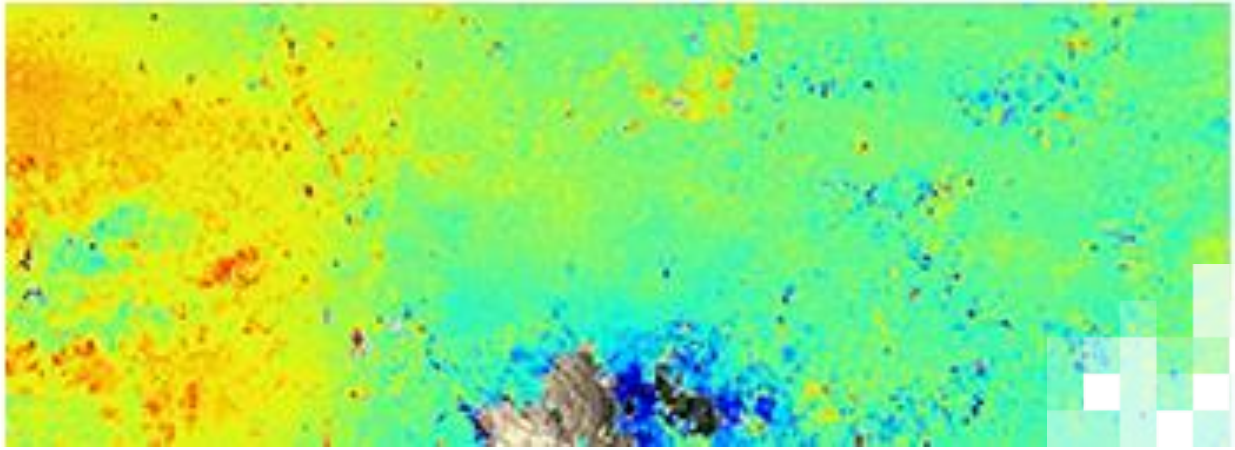
Harnessing NISAR: Next-Generation Radar Observations for Earth Applications

Session 1: An Introduction to NISAR

Erika Podest, Jet Propulsion Laboratory/California Institute of Technology

July 2, 2026





About ARSET

About ARSET

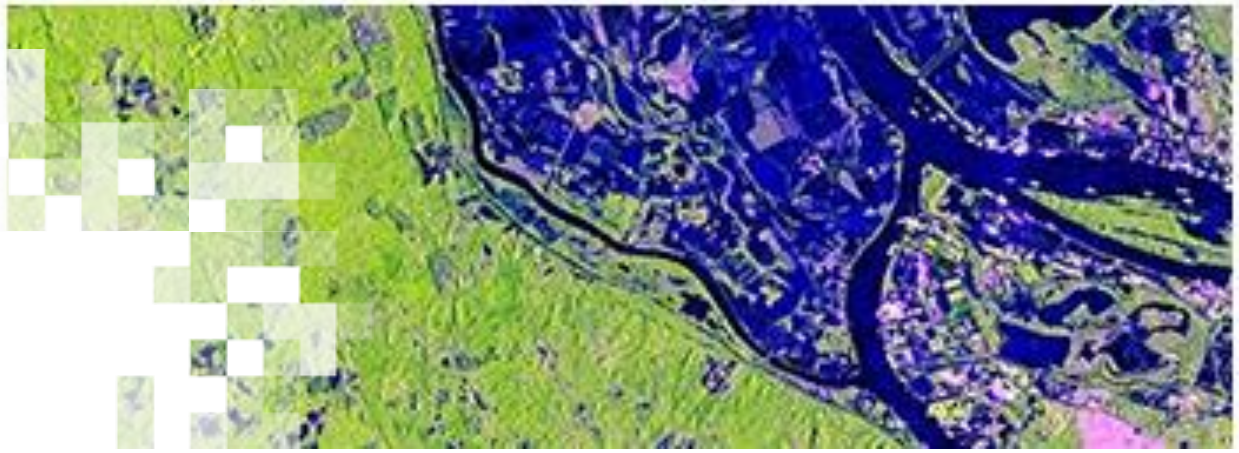
- **ARSET provides accessible, relevant, and cost-free training on remote sensing satellites, sensors, methods, and tools.**

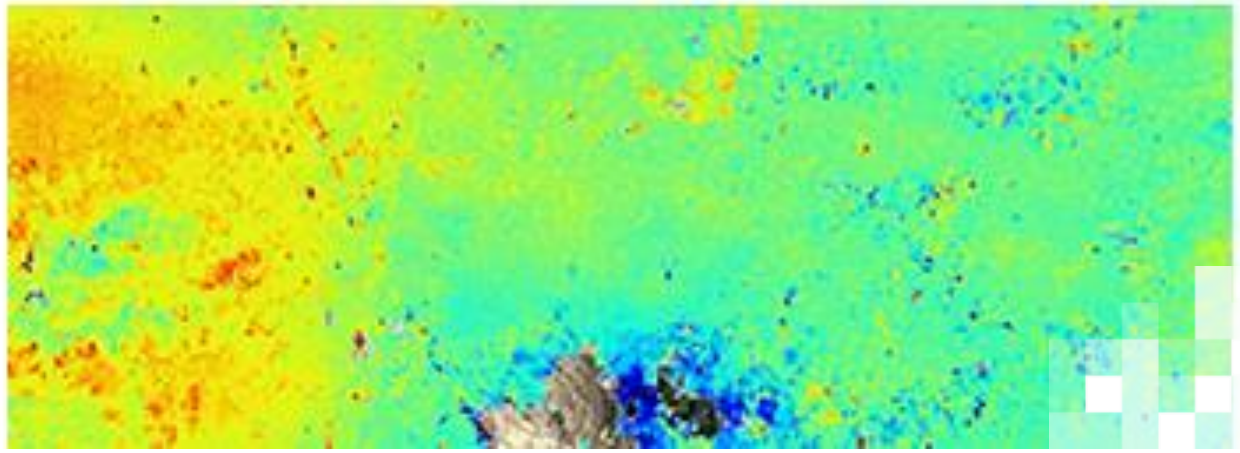
- Trainings include a variety of applications of satellite data and are tailored to audiences with a variety of experience levels.

About ARSET Trainings

- Online or in-person
- Live and instructor-led or asynchronous and self-paced
- Cost-free
- Bilingual and multilingual options
- Only use open-source software and data
- Accommodate differing levels of expertise

- Visit the ARSET website to learn more.





Overview

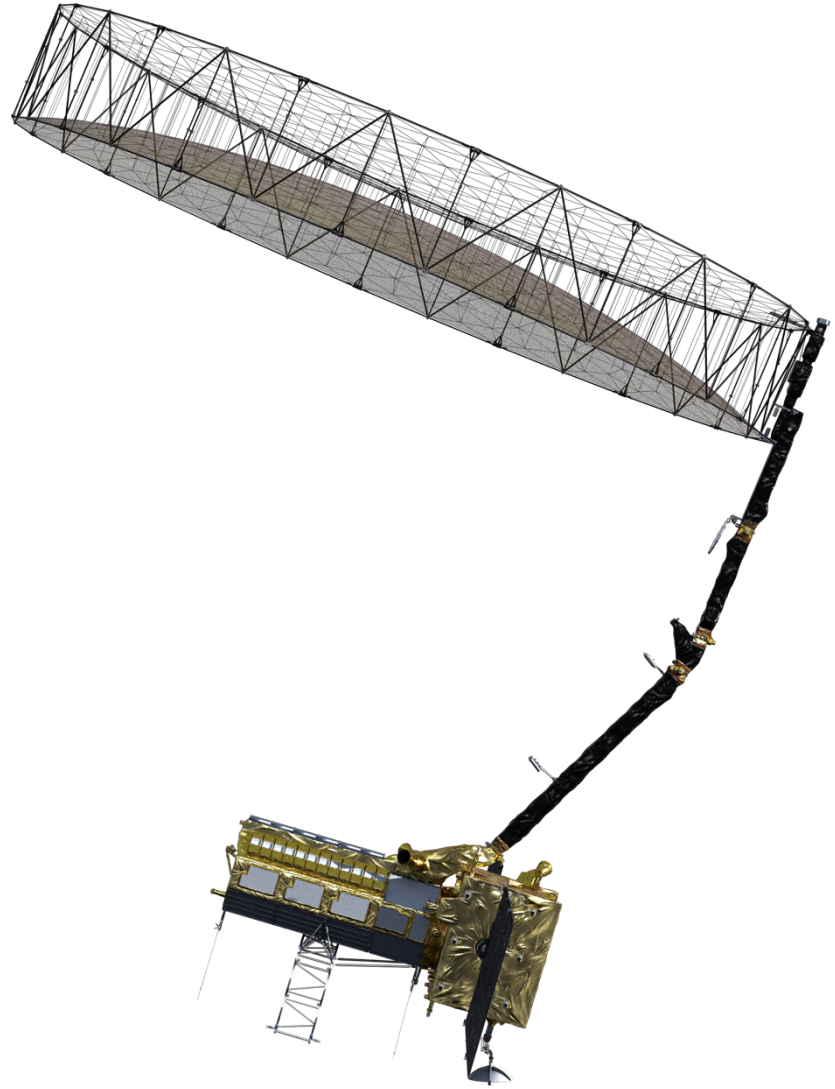
Harnessing NISAR: Next-Generation Radar Observations for Earth Applications

NISAR: A New Era of Earth Observation

Can We Measure Earth's Changing Surface Everywhere, All the Time?

NISAR will Provide:

- Global coverage
- Almost all-weather observations
- Day/night monitoring
- Systematic repeat measurements
- Capability to measure changes in the Earth’s surface from the centimeter to the meter scale



Training Learning Objectives

By the end of this webinar series, participants will be able to:

- Identify the characteristics, capabilities and limitations of NISAR data.
- Recognize how NISAR data can be applied to decision-making related to flooding, earthquakes, and landslides.
- Differentiate between the various NISAR data products and their applicability for different use cases.
- Demonstrate how to access NISAR data and tools via the ASF DAAC platform to search, visualize and analyze data for provided case studies related to floods, earthquakes, and landslides, agriculture.
- Generate a flood map, landslide risk map, and volcano deformation map for events of interest using interferogram (GUNW) files in QGIS.
- Demonstrate how to access NISAR S-band data via the ISRO Bhoonidhi platform and use available tools for basic visualization and analysis.

Prerequisites

- Fundamentals of Remote Sensing
- An Introduction to Synthetic Aperture Radar (SAR) and its Applications
- Quick review of synthetic aperture radar interferometry theory
- See the 2017 ARSET training session "Introduction to SAR Interferometry" for more details
- In SAR interferometry, it is all about the phase of the SAR signal

Training Outline

Session 1

An Introduction to NISAR

July 2, 2026

11:30 a.m. - 1:30 p.m. EDT

(1530-1730 UTC)

Session 2

NISAR Data Access and Tools

July 9, 2026

11:30 a.m. - 1:30 p.m. EDT

(1530-1730 UTC)

Session 3

Monitoring Earthquakes, Volcanoes, and Landslides with NISAR's InSAR Capability

July 16, 2026

11:30 a.m. - 1:30 p.m. EDT

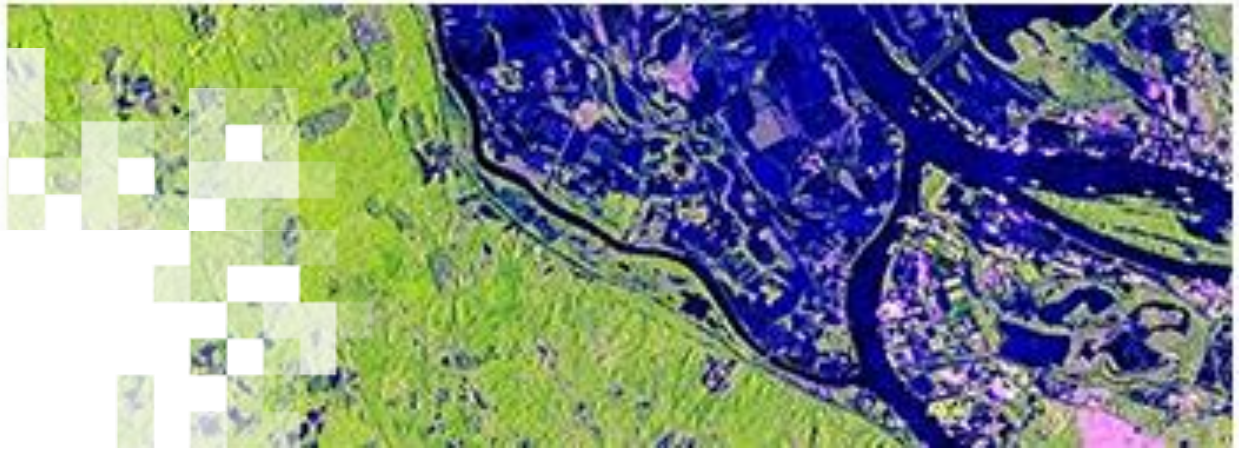
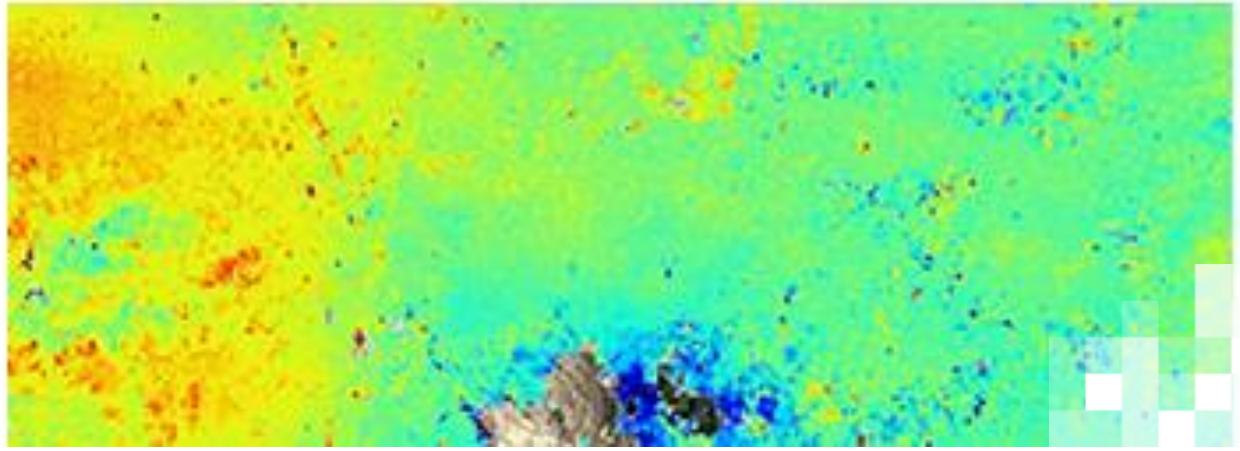
(1530-1730 UTC)

Homework

Opens July 16, 2026– Due Aug. 6, 2026 – Posted on Training Webpage

A certificate of completion will be awarded to those who attend all live sessions and complete the homework assignment by the given due date.



Session 1: An Introduction to NISAR

Session 1 – Trainer

Erika Podest, Ph.D.

Scientist

NASA Jet Propulsion Laboratory

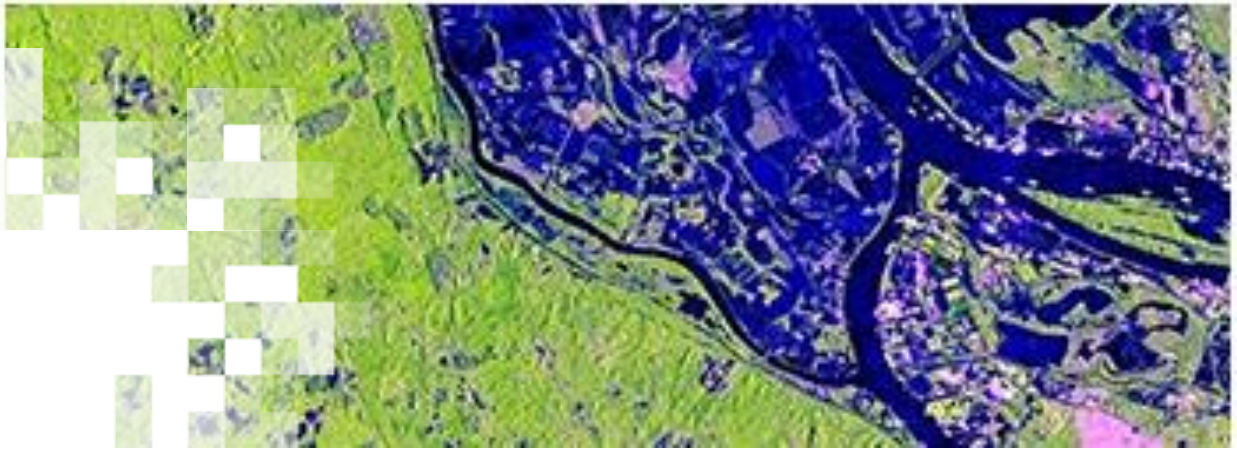
Session 1 Objectives

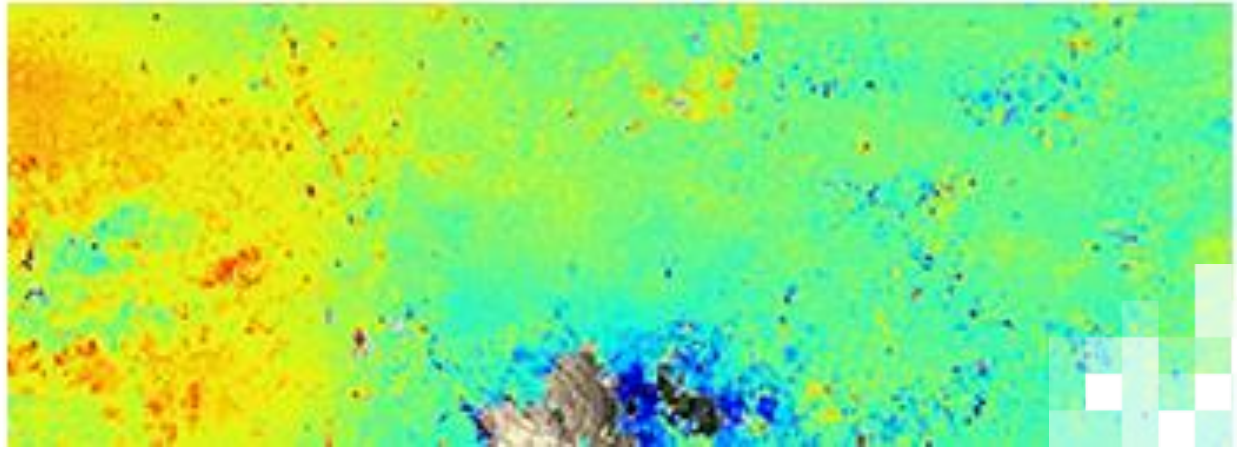
By the end of this session, participants will be able to:

- Identify the characteristics, capabilities and limitations of NISAR data.
- Recognize how NISAR data can be applied to decision-making related to flooding, earthquakes, and landslides.
- Identify the different NISAR data products.

How to Ask Questions

- To ensure we see your question, please locate the three dots (...) at the bottom-right of your training window.
- You will see a Slido/Q&A option. You may also see a standalone Slido tab or app.
- Please place all questions there and we will answer them during the Q&A session.
- We will try to get to all of the questions during the Q&A session after the webinar. The remainder of the questions will be answered in the Q&A document, which will be posted to the training website about a week after the training.



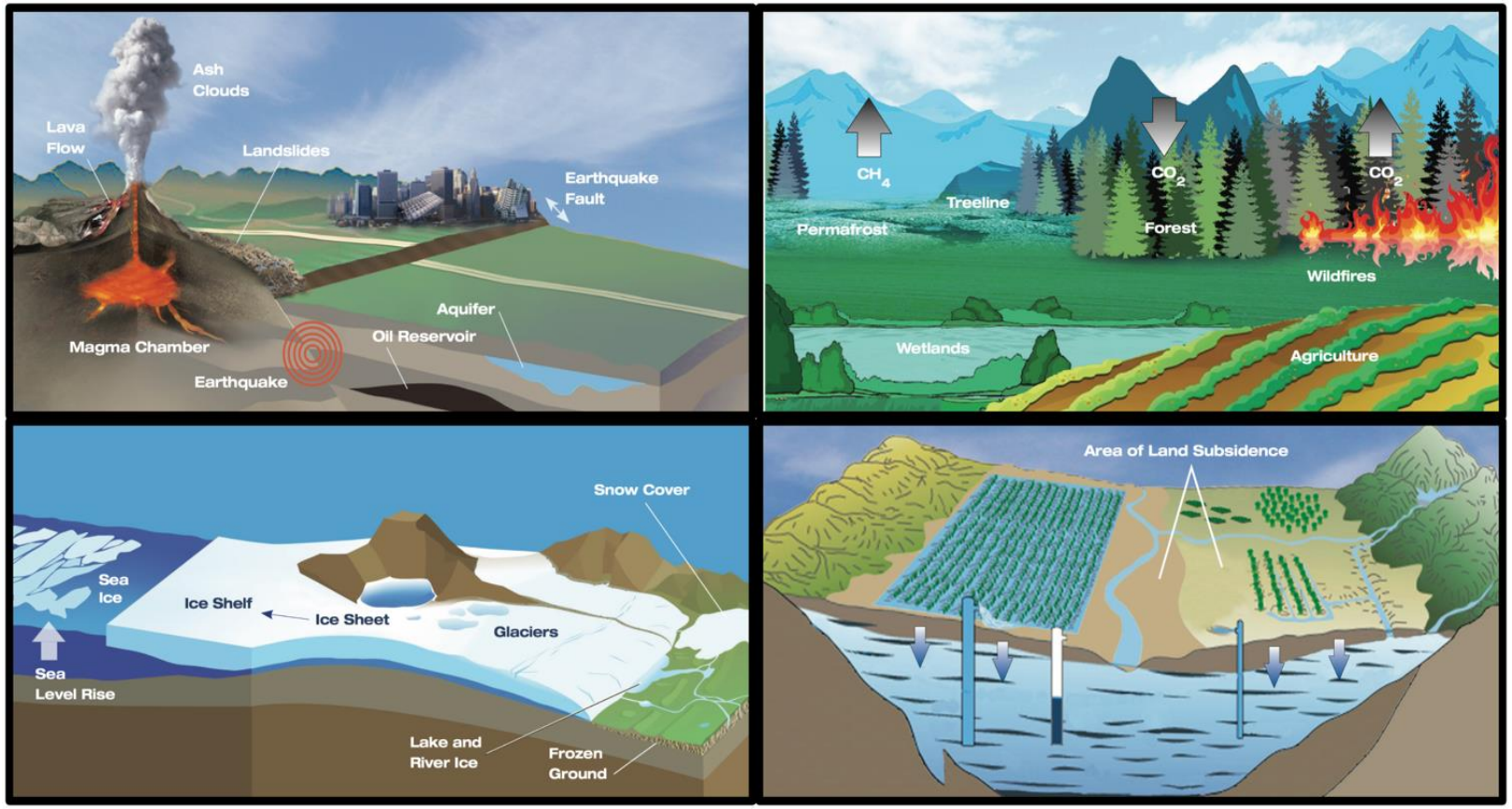


Session 1:

The NISAR Mission

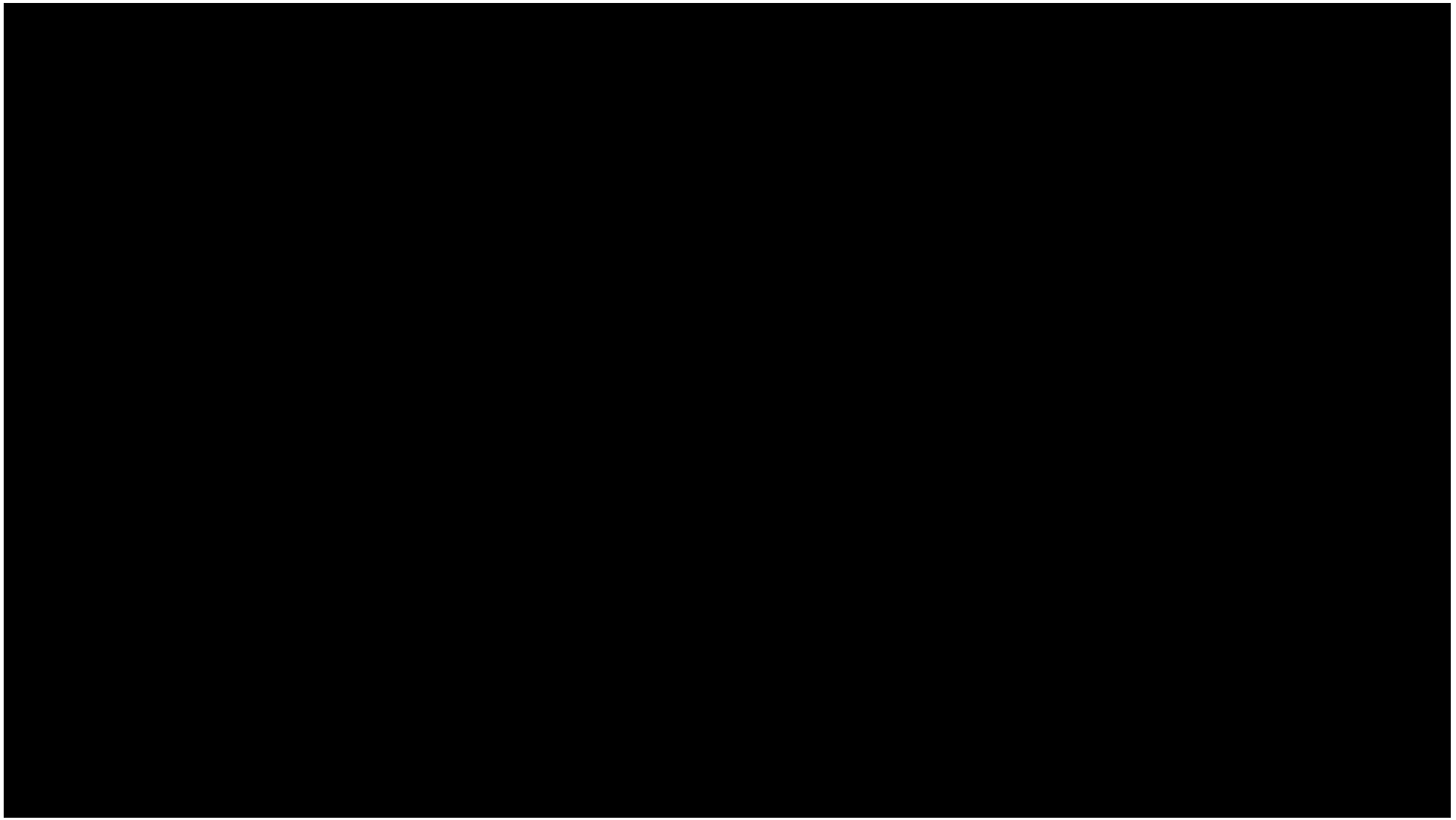
NISAR: Capturing a Dynamic Earth

- Earthquakes and Tectonic Deformation
- Glacier and Ice Sheet Motion
- Forest Change and Biomass
- Agriculture and Soil Moisture
- Landslides
- Surface Subsidence
- Floods and Wetlands

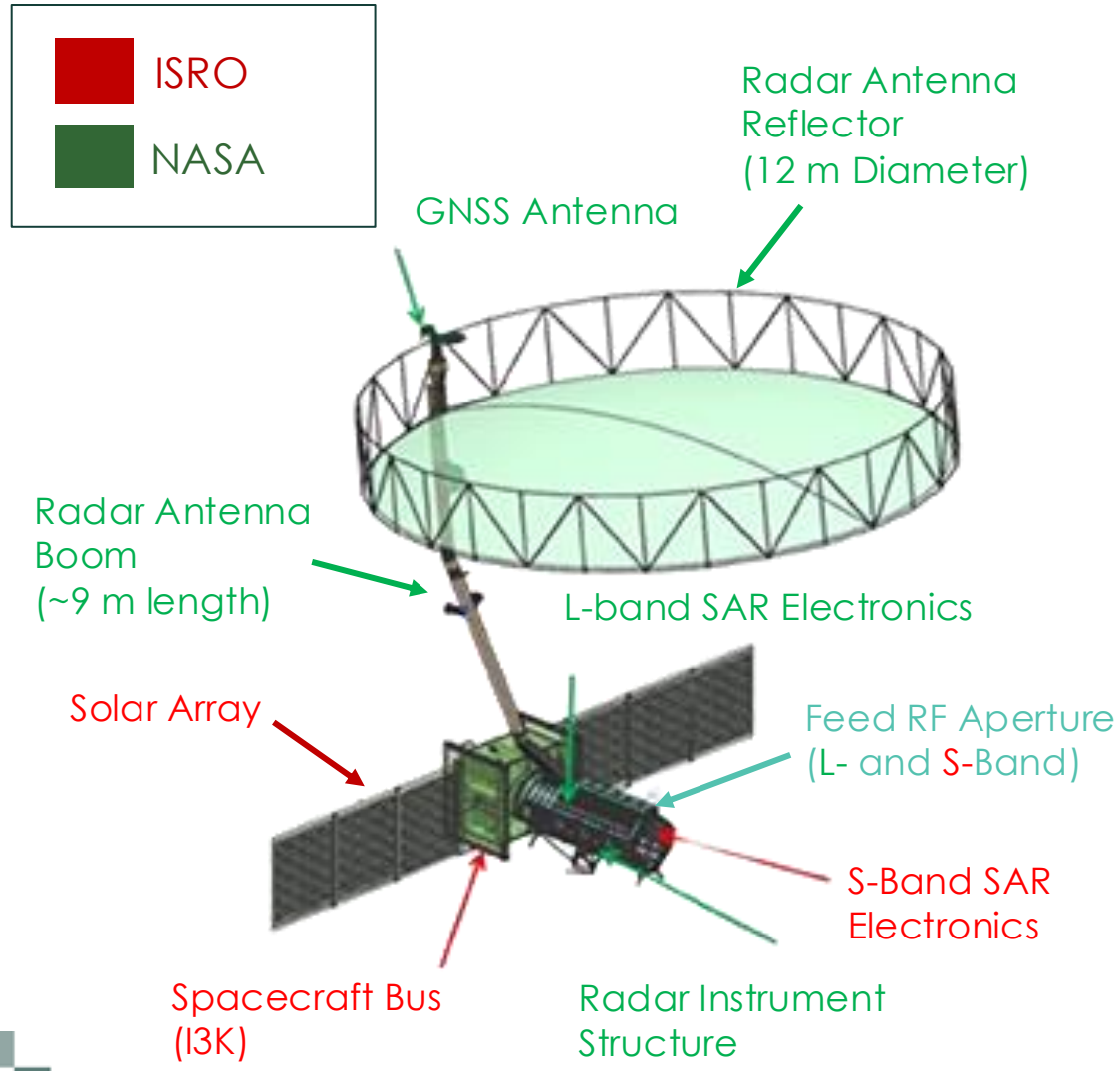


We need a sensor that works day and night, through clouds, and with high spatial resolution.

The NISAR Mission



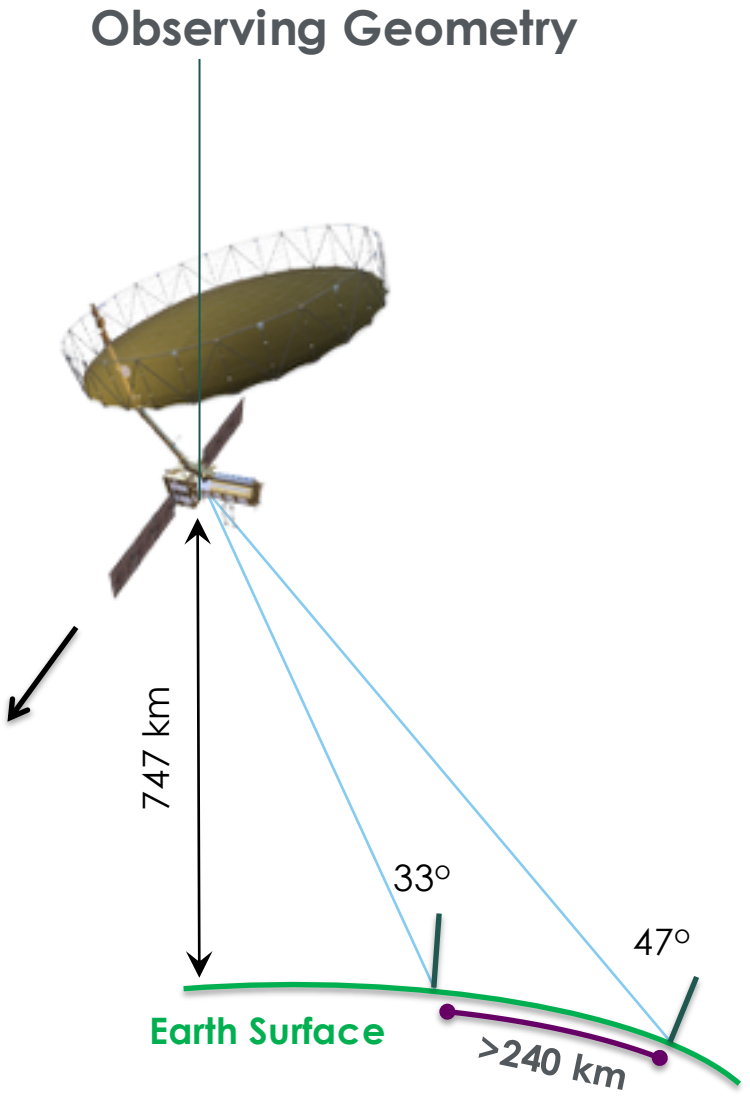
NASA-ISRO SAR Mission: Close Integration Between International Partners



NASA Provides	ISRO Provides
• L-band SAR • Shared P/L structure & 12m reflector and boom	• S-band SAR • S-SAR baseband data handling (BDH)
• Engineering payload - GPS, Power & Pyro - Payload Data System with 12 Tb recorder - Near-Earth-Network-compatible high-rate Ka-band system	• Spacecraft Bus (I3K) • ISRO-compatible high-rate Ka-band system • Observatory I&T • GSLV Launch Vehicle
Integrated radar observation planning and operations	Spacecraft operations (command uplink, telemetry and tracking)
L-SAR data downlink to NSN Ka-band stations	S-SAR, select L-SAR data downlink to ISRO stations
L-band science data processing and distribution	S-band science data processing and distribution
NASA Science Team	ISRO Science Team

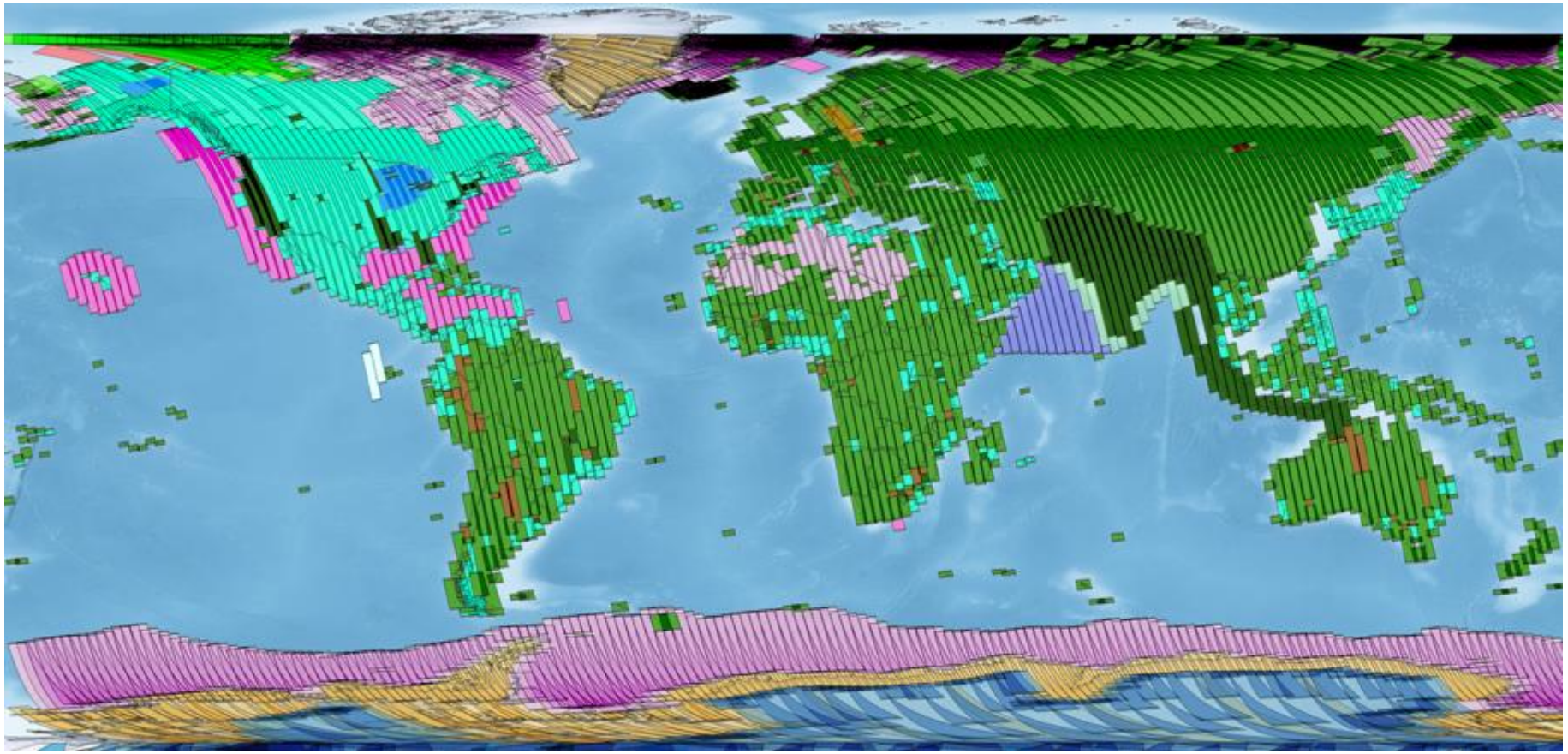
NISAR Characteristics

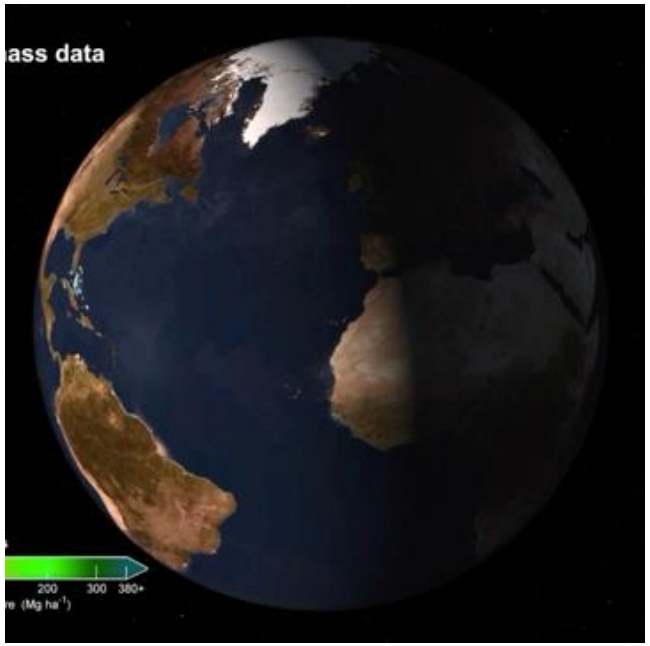
NISAR Characteristic:	Enables:
L-band (24 cm wavelength)	Low temporal decorrelation and foliage penetration
S-band (9.4 cm wavelength)	Sensitivity to light vegetation
SweepSAR technique with Imaging Swath > 240 km	Global data collection
Polarimetry (Single/Dual/Quad)	Surface characterization and biomass estimation
12-day exact repeat	Rapid sampling
3 – 10 meters mode-dependent SAR resolution	Small-scale observations
3 yrs (NASA) / 5 yrs (ISRO) science operations	Time-series analysis
Pointing control < 273 arcseconds	Deformation interferometry
Orbit control < 500 meters	Deformation interferometry
> 10% (S) / 50% (L) observation duty cycle	Complete land/ice coverage
Left-only pointing (Left/Right capability)	Uninterrupted time-series Rely on Sentinel-1 for Arctic



NISAR Characteristics

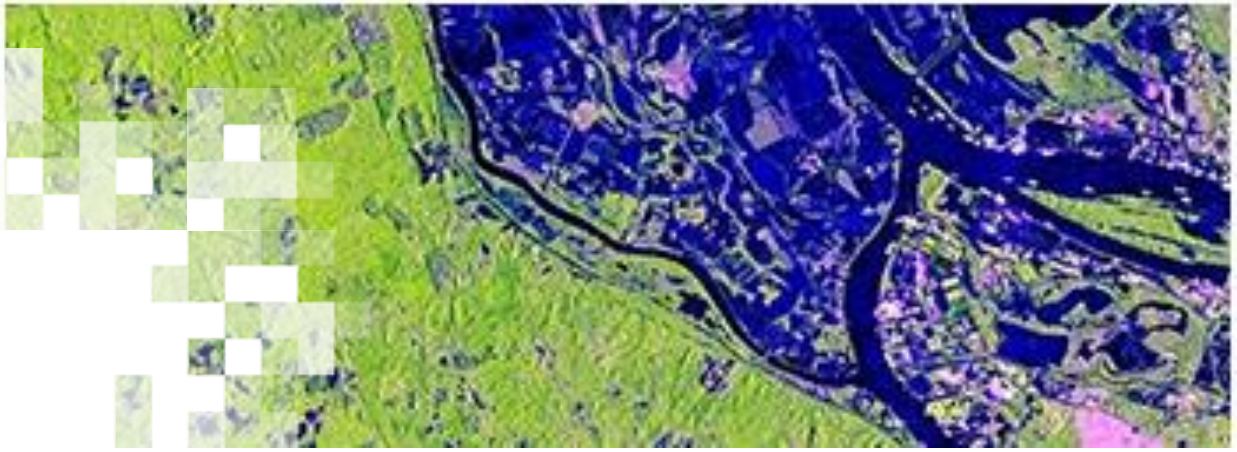
Land and Ice-Covered Surfaces, plus Selected Coastal Areas

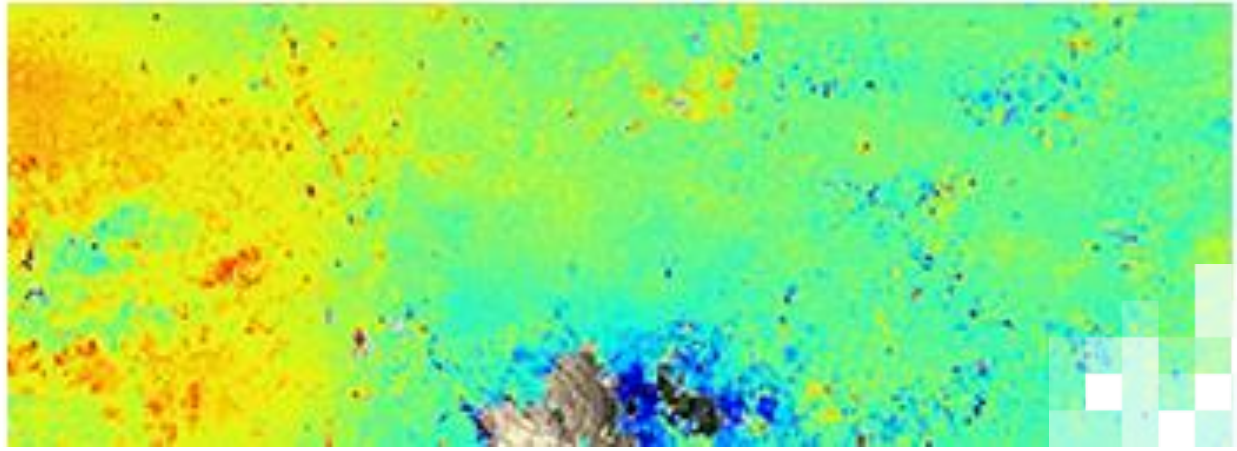




Sun-Synchronous 6 am/6 pm Orbit

Colors indicate specific radar modes (resolution, polarization, L/S/L+S-band), repeated every 12 days.





Why Radar?

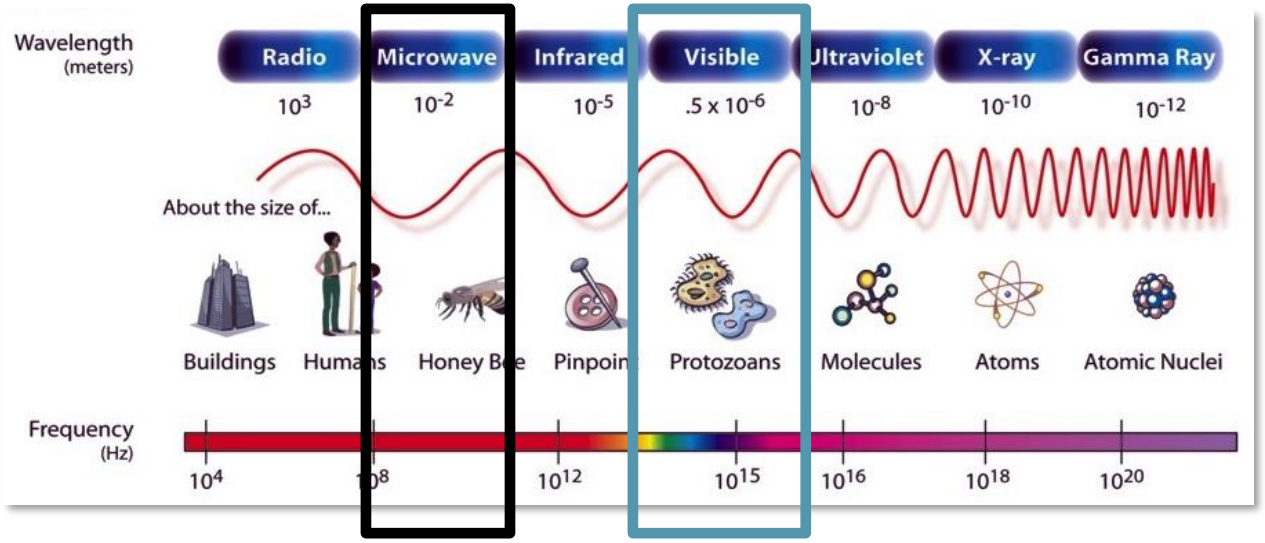
Advantages and Disadvantages of Radar Over Optical Remote Sensing

Advantages:

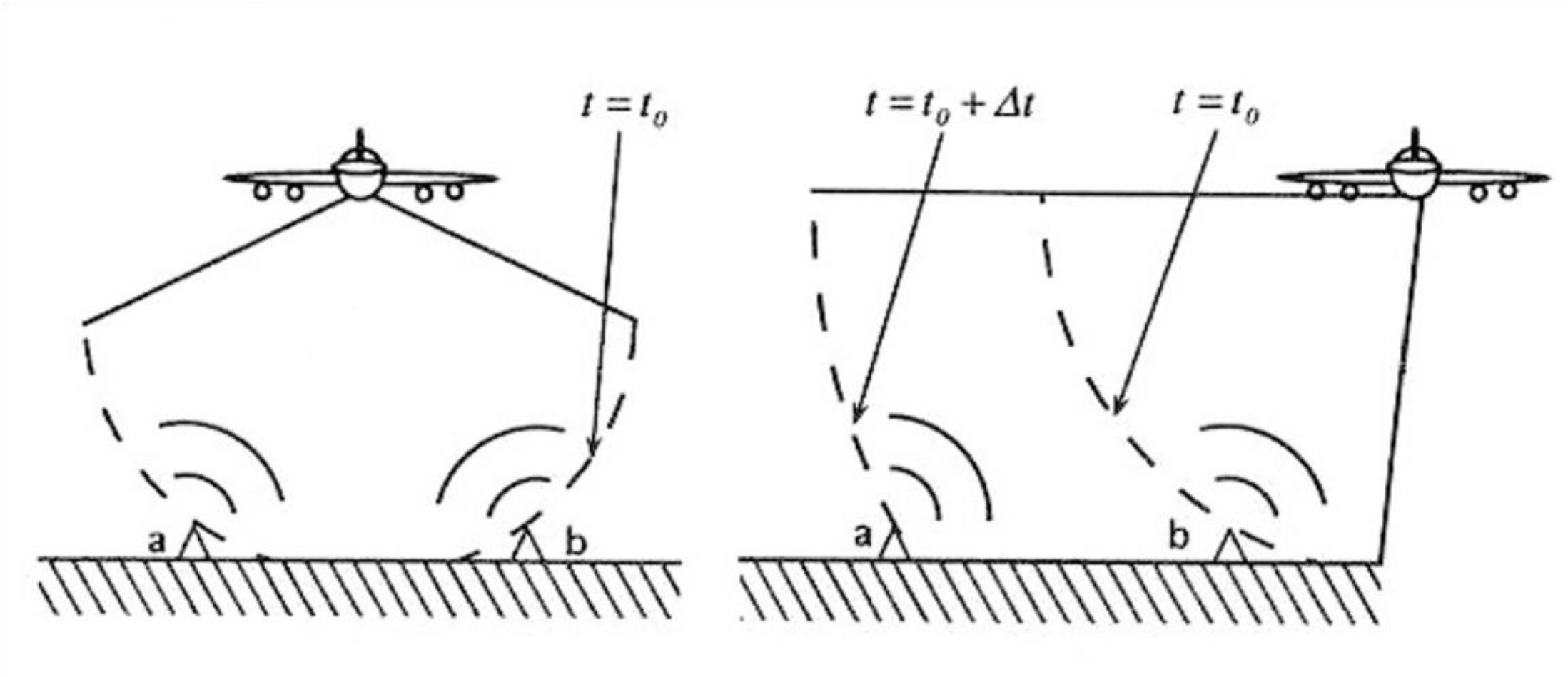
- Nearly all-weather capability
- Day or night capability
- Penetration through the vegetation canopy
- Penetration through the soil
- Minimal atmospheric effects
- Sensitivity to dielectric properties (liquid vs. frozen water)
- Sensitivity to structure

Disadvantages:

- Information content is different than optical and sometimes difficult to interpret
- Speckle effects (graininess in the image)
- Effects of topography

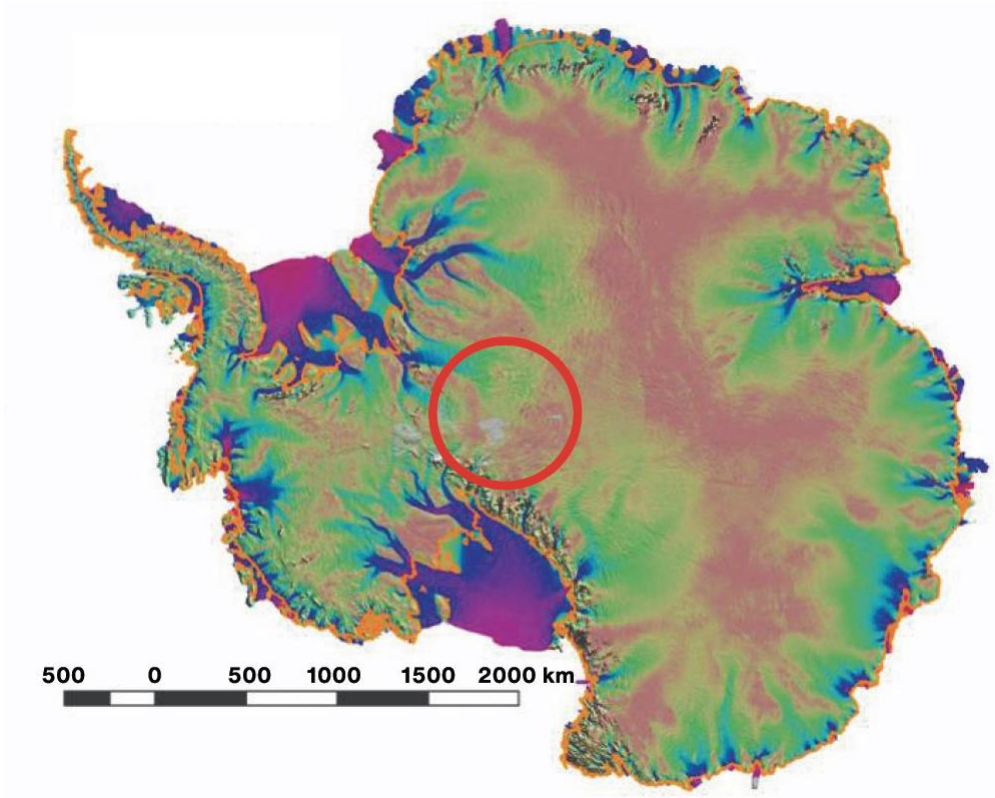


Down-Looking vs. Side-Looking Radar

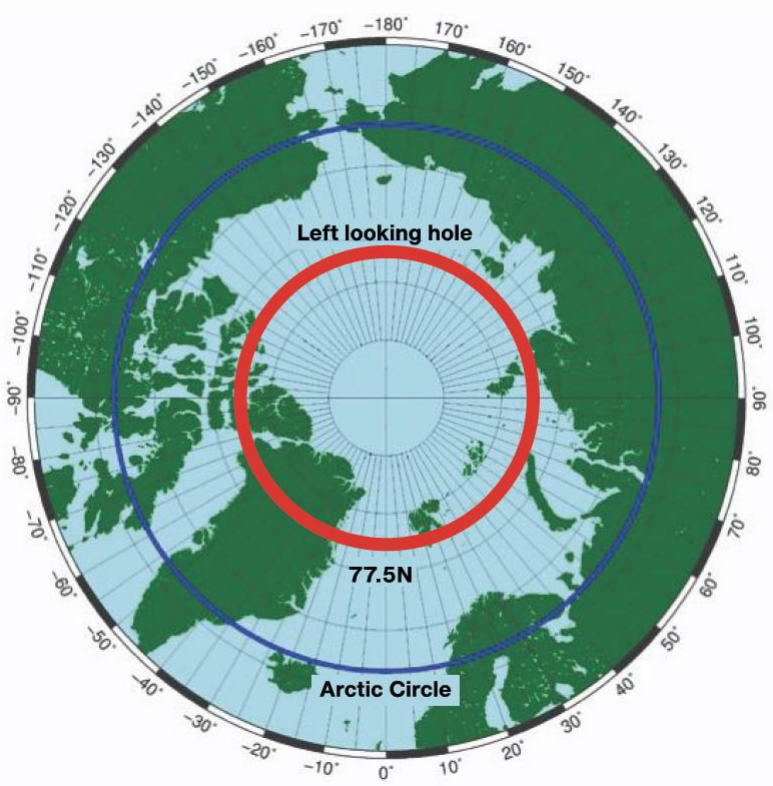


NISAR: Left-Looking Radar

Antarctica



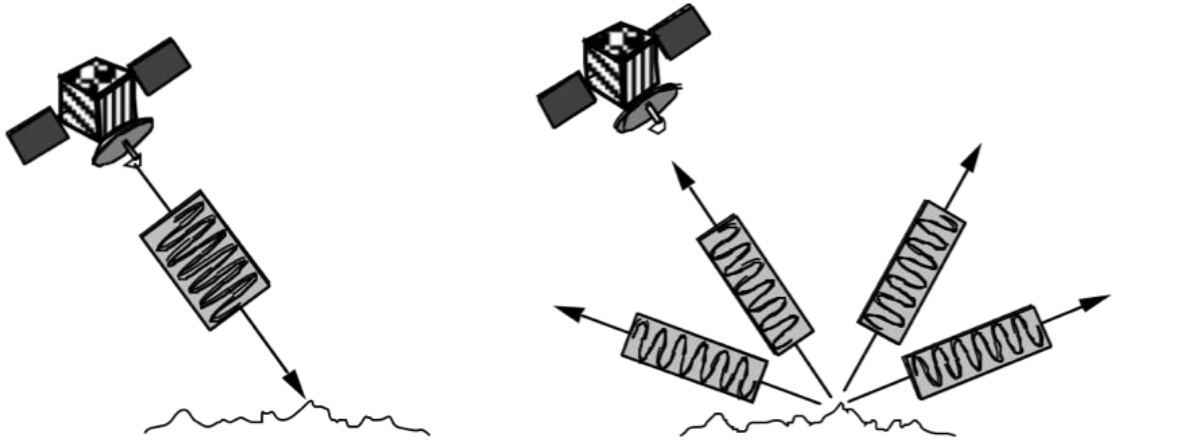
Arctic

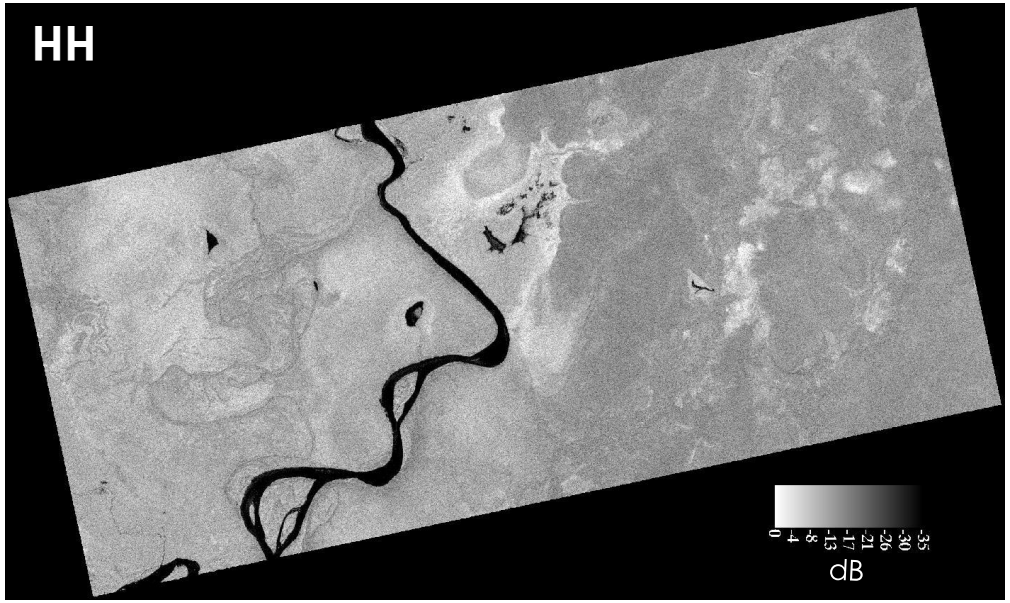


The red circles represent the gap in NISAR coverage.

Review of Radar Image Formation: Amplitude

1. Radar can measure **amplitude** (the strength of the reflected echo) and **phase** (the position of a point in time on a waveform cycle).
2. Radar can only measure the part of the echo reflected back towards the antenna (**backscatter**).
3. Radar pulses travel at the **speed of light**.
4. The strength of the reflected echo is the backscattering coefficient (**sigma naught**) and is expressed in decibels (**dB**).

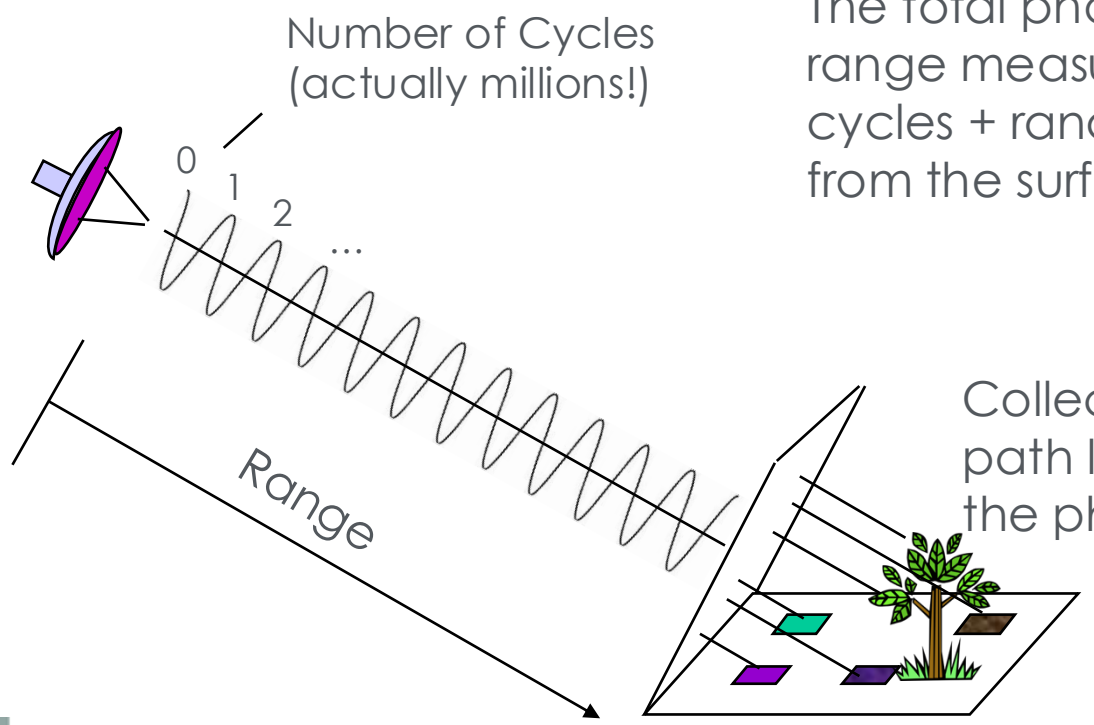




Source: ESA-ASAR Handbook

Review of Radar Image Formation: Phase

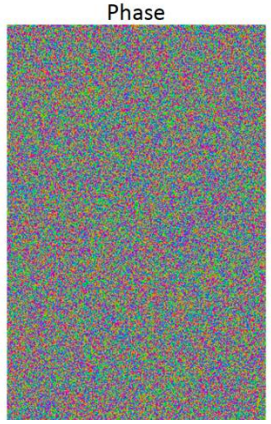
- The phase of the radar signal is the number of **cycles of oscillation** that the wave executes between the radar and the surface and back again.



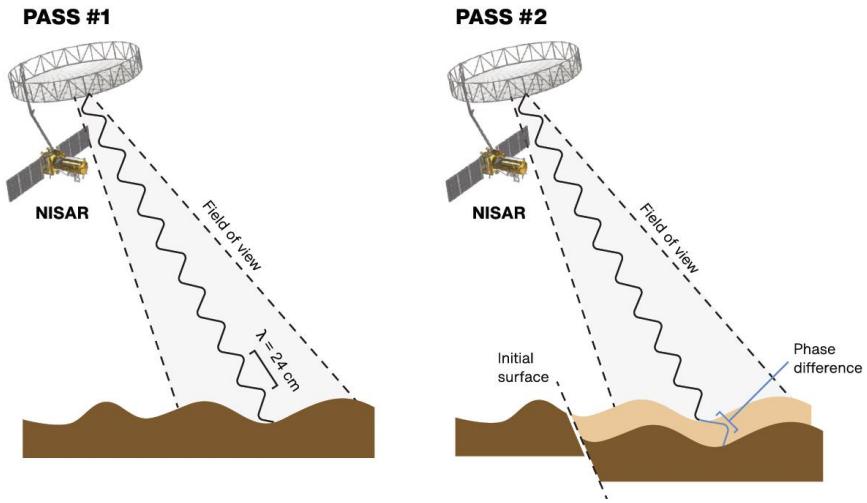
The total phase is two-way range measured in wave cycles + random component from the surface.

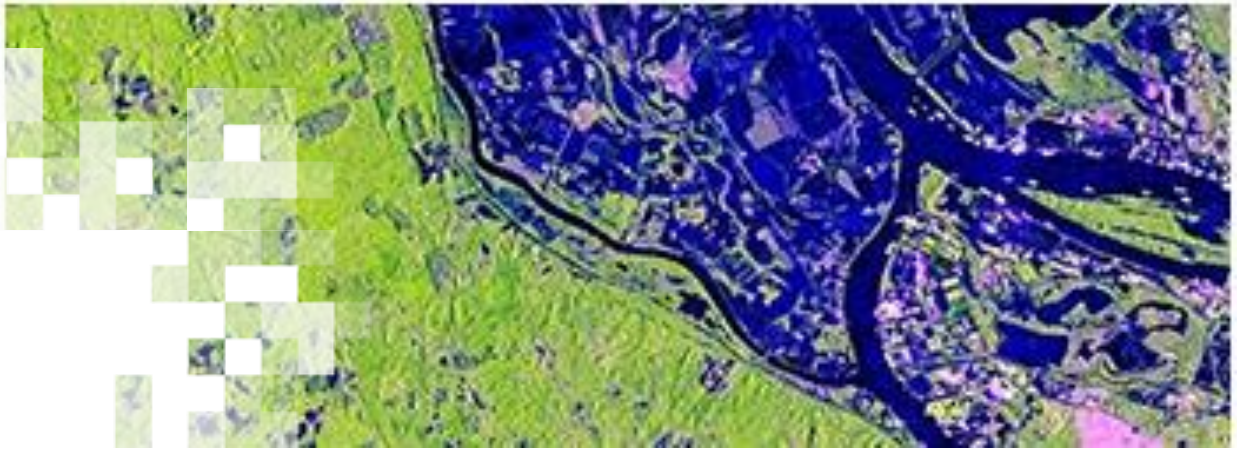
Collection of random path lengths jumbles the phase of the echo.

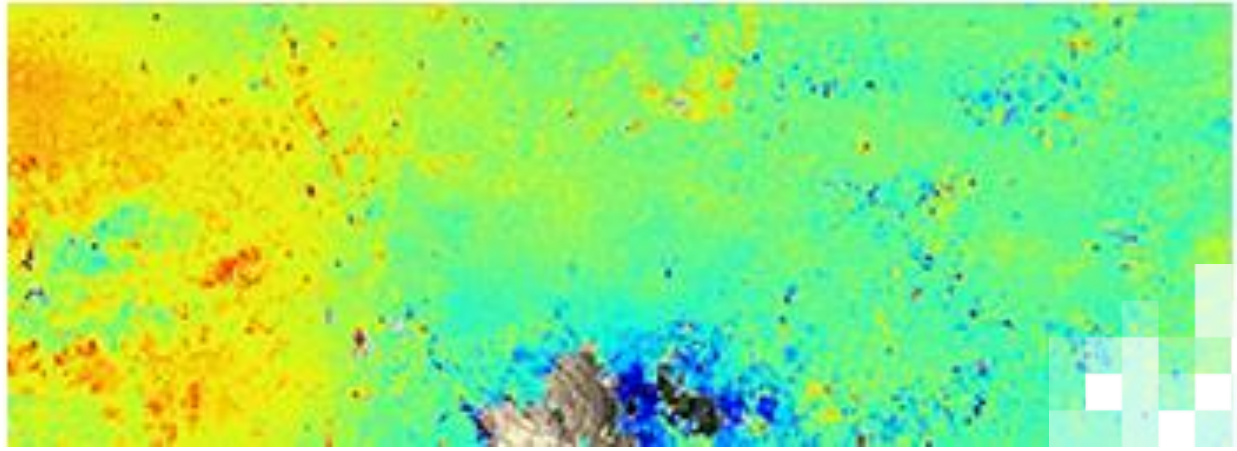
Only **interferometry** can sort it out!



NISAR Repeat Pass Interferometry



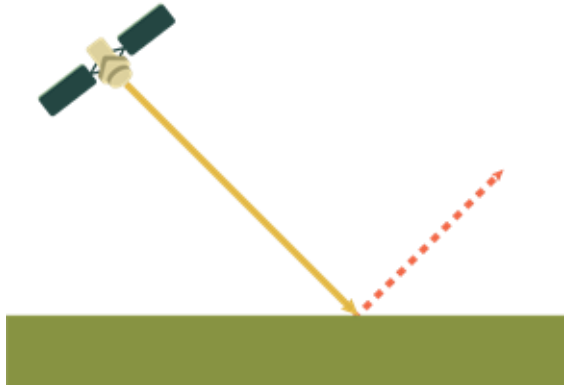




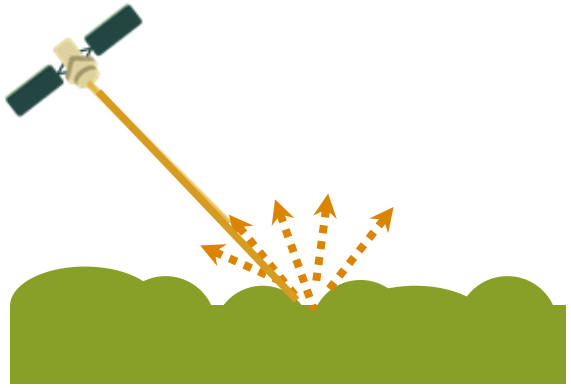
Radar Scattering Mechanisms

Radar Signal Interaction

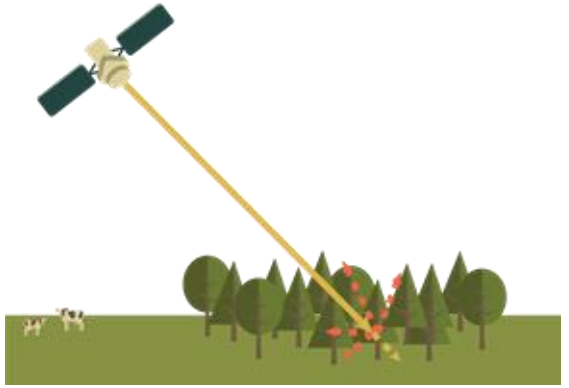
Radar Backscattering Mechanisms:



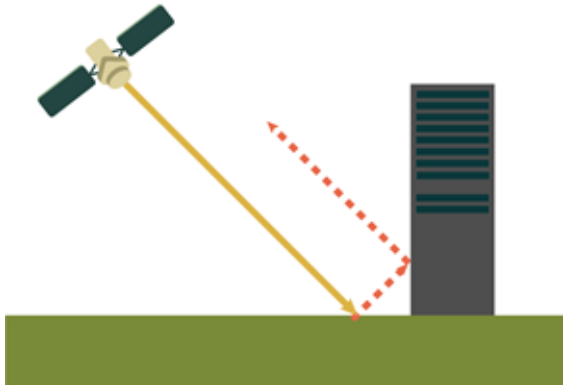
Smooth Surface
(Specular Reflector)



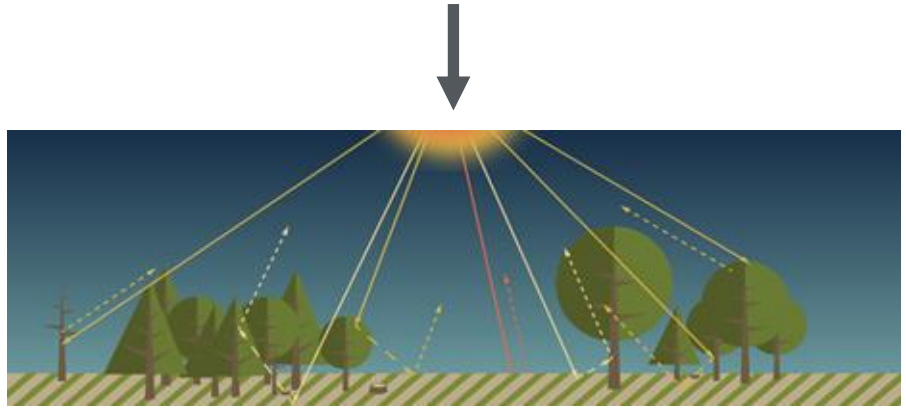
Rough Surface



Volumetric

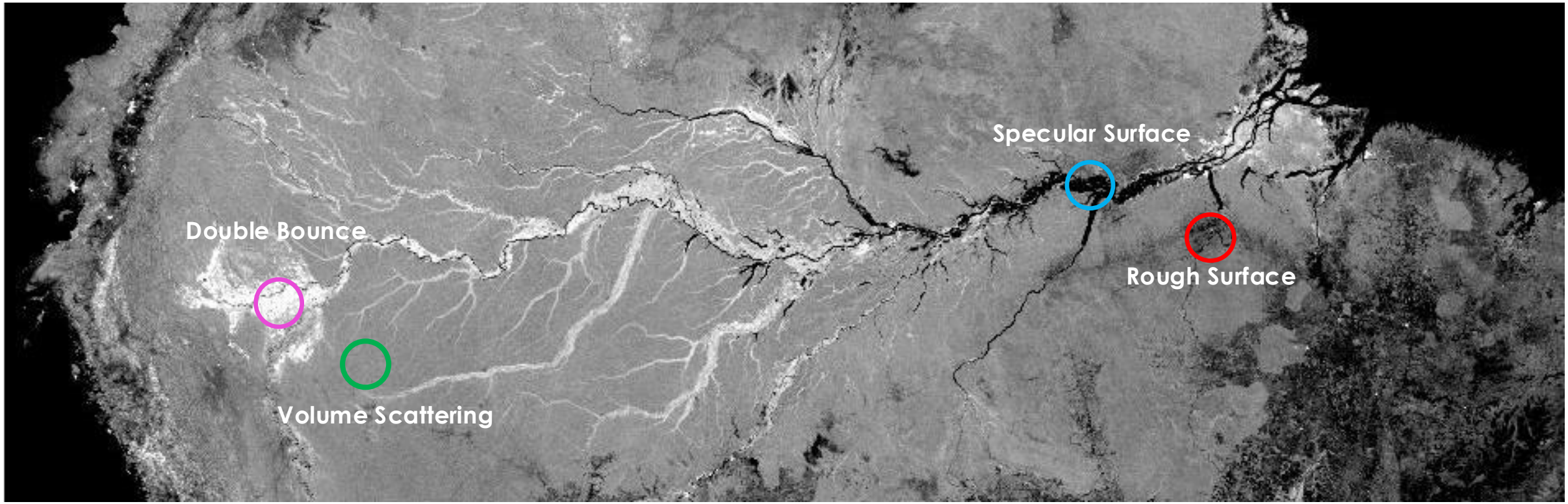


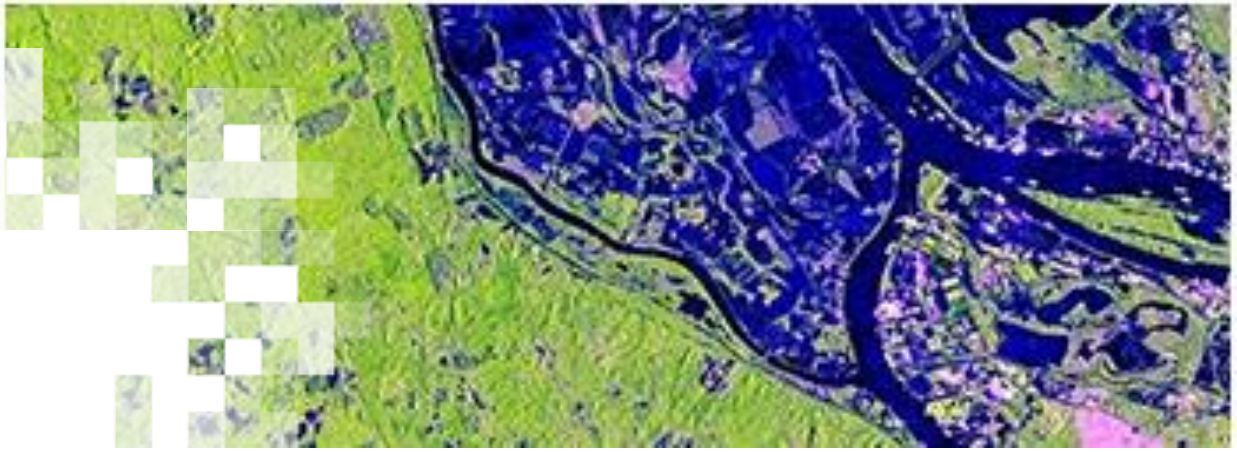
Double Bounce

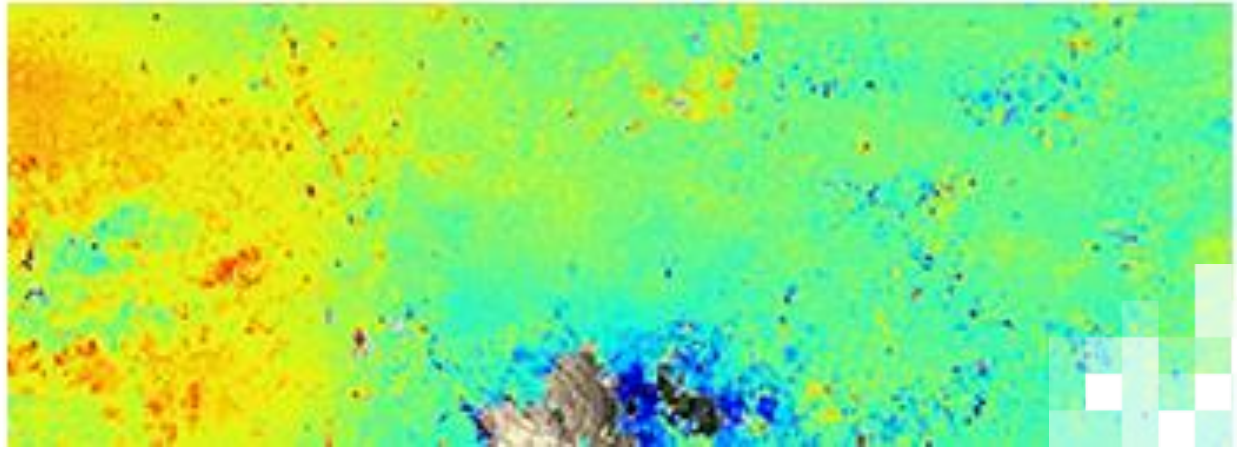


Backscattering Mechanisms

SMAP Radar Mosaic of the Amazon Basin
April 2015 (L-band, HH, 3 km)







Radar and Surface Parameters

Radar Parameters: Wavelength

$$\lambda = \frac{c}{v}$$

c = Speed of Light ($3x10^8$ m/s)
λ = Wavelength (m)
v = Frequency (cycles per second, Hz)

Higher Frequency
Shorter Wavelength

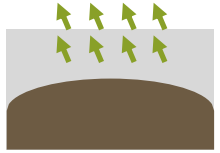
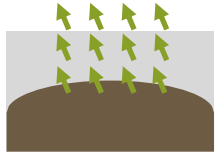
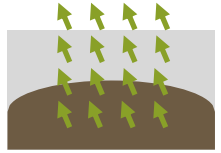
Lower Frequency
Longer Wavelength

Band Designation*	Wavelength (λ), cm	Frequency (v), GH_z (10^9 cycles·sec^{-1})
Ka (0.86 cm)	0.8 – 1.1	40.0 – 26.5
K	1.1 – 1.7	26.5 – 18.0
Ku	1.7 – 2.4	18.0 – 12.5
X (3.0 cm, 3.2 cm)	2.4 – 3.8	12.5 – 8.0
C (6.0)	3.8 – 7.5	8.0 – 4.0
S	7.5 – 15.0	4.0 – 2.0
L (23.5 cm, 25 cm)	15.0 – 30.0	2.0 – 1.0
P (68 cm)	30.0 – 100.0	1.0 – 0.3

* () show wavelengths most frequently used in SAR.

Signal Penetration as a Function of Wavelength

- Signal penetration is the **primary factor** in wavelength selection.
- Generally, the longer the wavelength, the greater the penetration into the target.

Vegetation			
Dry Alluvium			
	X-Band 3 cm	C-Band 5 cm	L-Band 24 cm

Frequency Band	Application Example
P-Band	Biomass, Soil Moisture, Penetration
L-Band	Agriculture, Forestry, Soil Moisture
S-Band	Agriculture, Forestry, Wetlands
C-Band	Ocean, Agriculture
X-Band	Agriculture, Ocean, High-Resolution Radar
Ku-Band	Glaciology (Snow Cover Mapping)

Image Based On ESA Radar Course 2

Radar Parameter: Polarization

- **Polarization:** The orientation of the electric field of the electromagnetic wave.
- The polarizations are usually controlled between **H** and **V**:
  - HH: Horizontal Transmit, Horizontal Receive
  - VV: Vertical Transmit, Vertical Receive
  - HV: Horizontal Transmit, Vertical Receive
  - VH: Vertical Transmit, Horizontal Receive

- **Quad-Pol Mode:** When all four polarizations are measured.
- Different polarizations can determine physical properties of the object observed.

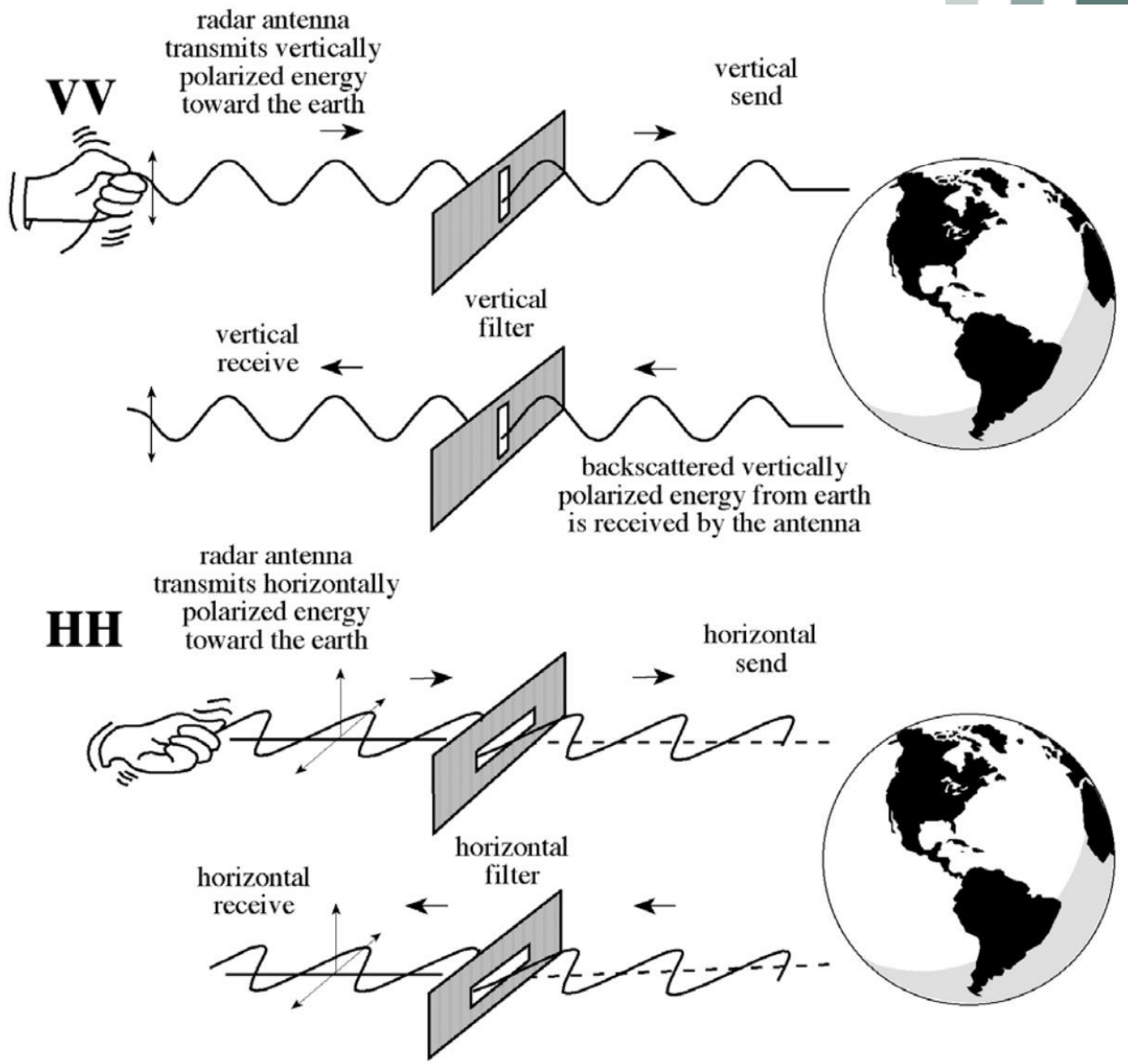


Image Credit: J.R. Jensen, 2000. Remote Sensing of the Environment

Surface Parameter: Structure

Size & Orientation

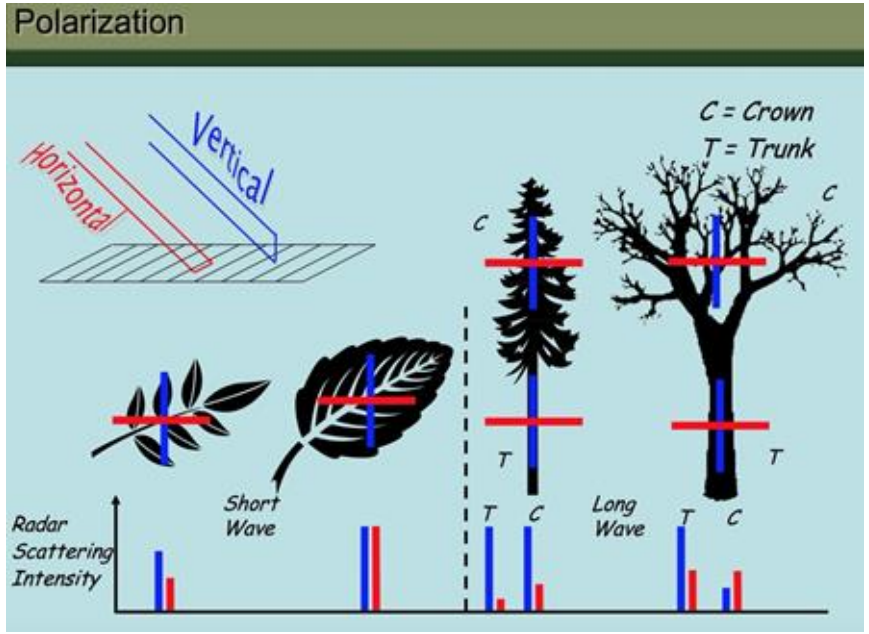


Image Credit: Walker, W. *Introduction to Radar Remote Sensing for Vegetation Mapping and Monitoring*

Size Relative to Wavelength

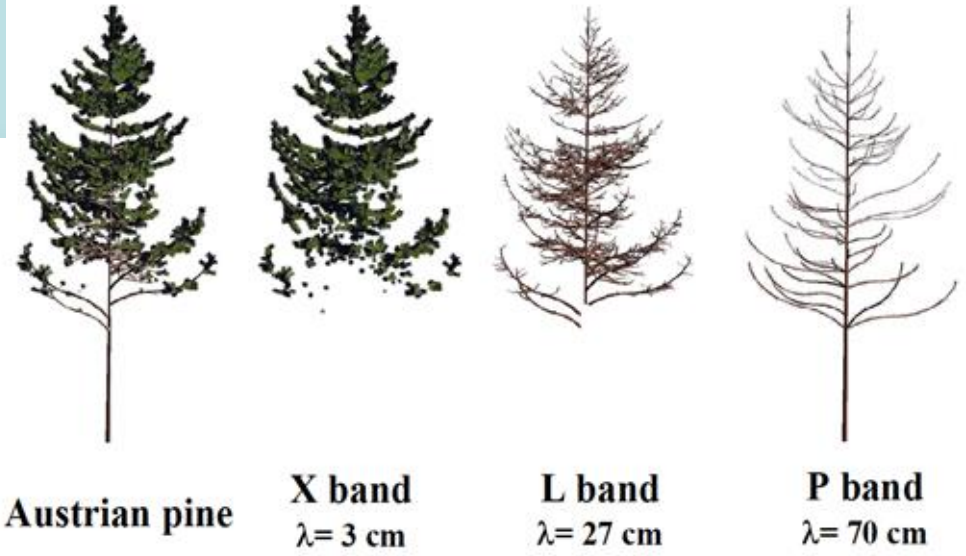


Image Credit: Thuy le Toan

Density

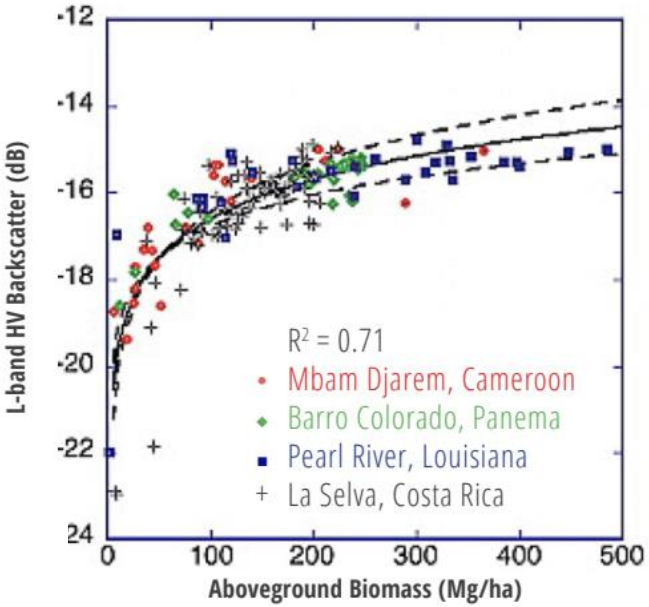
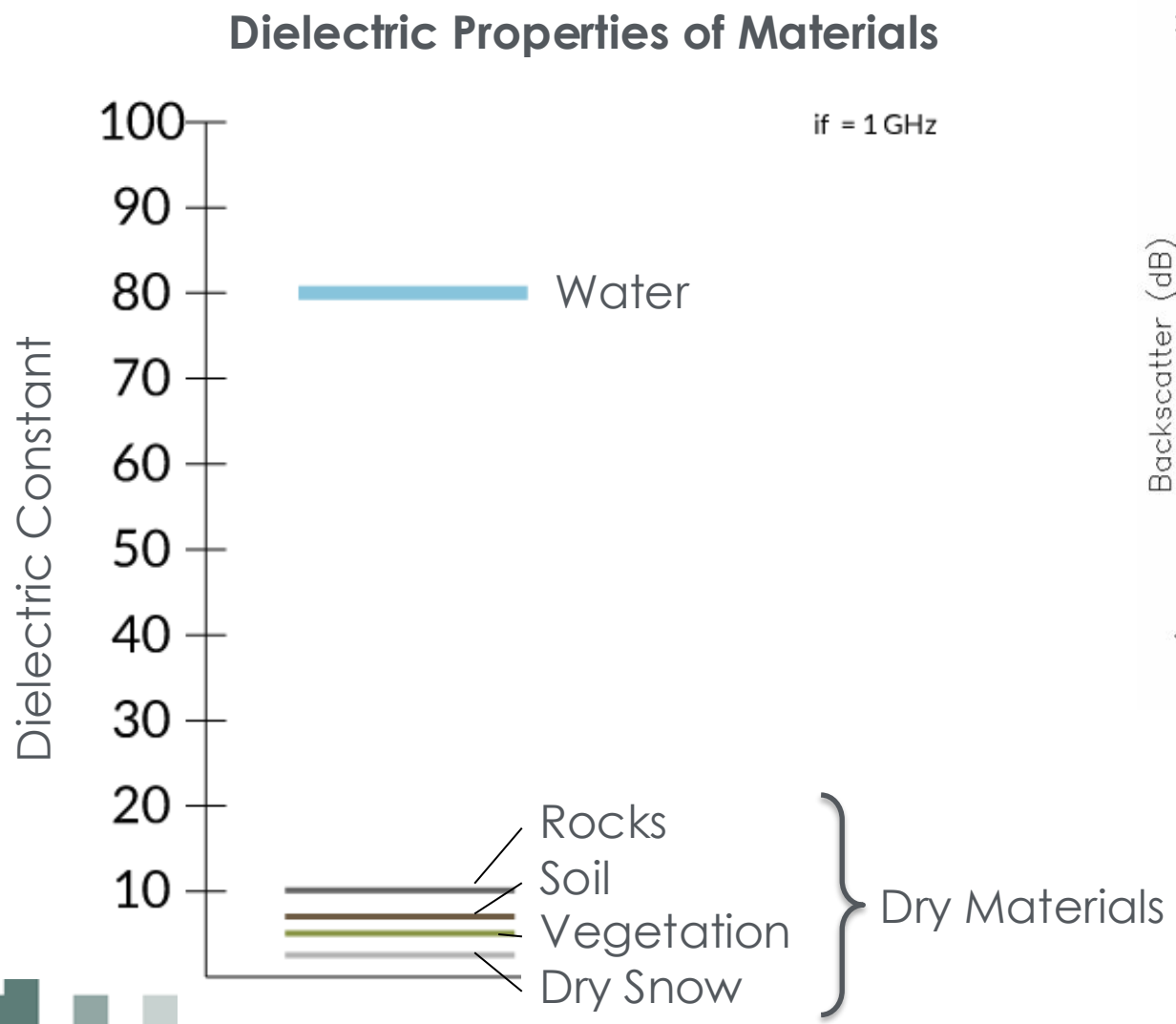
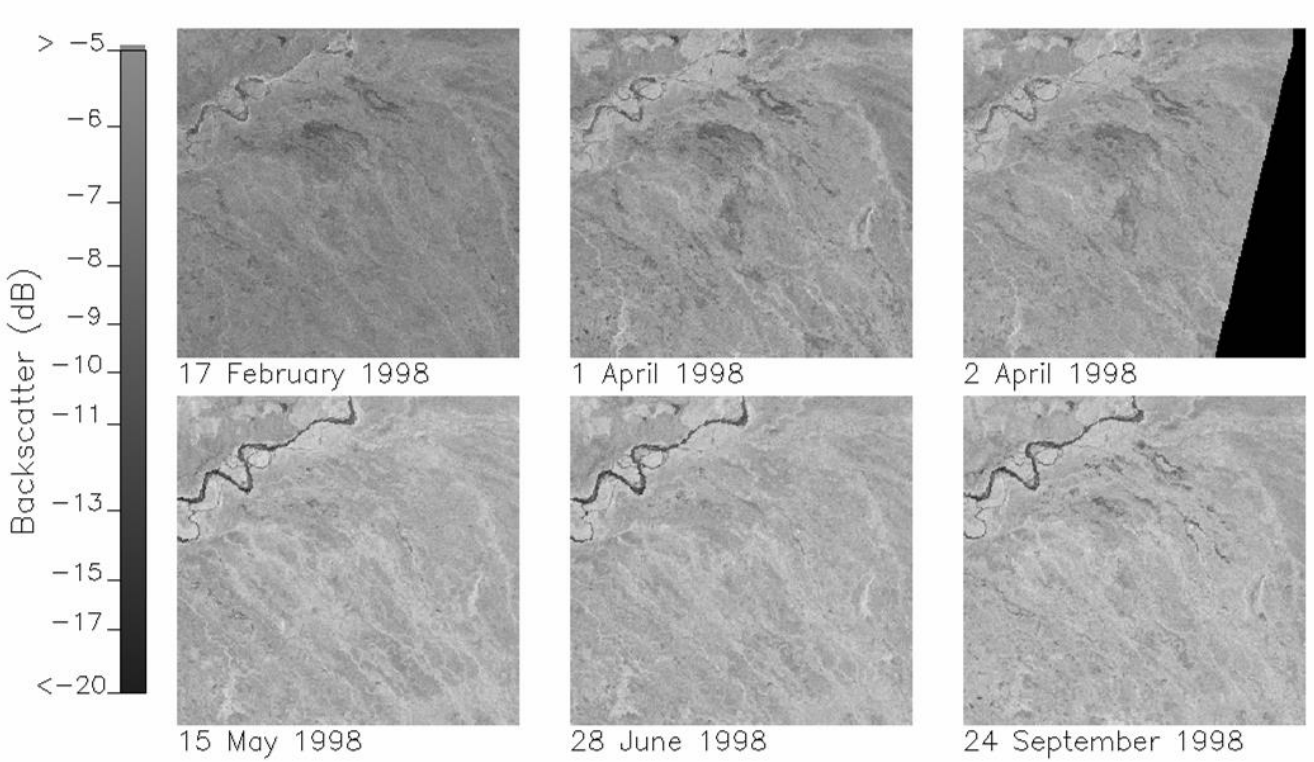


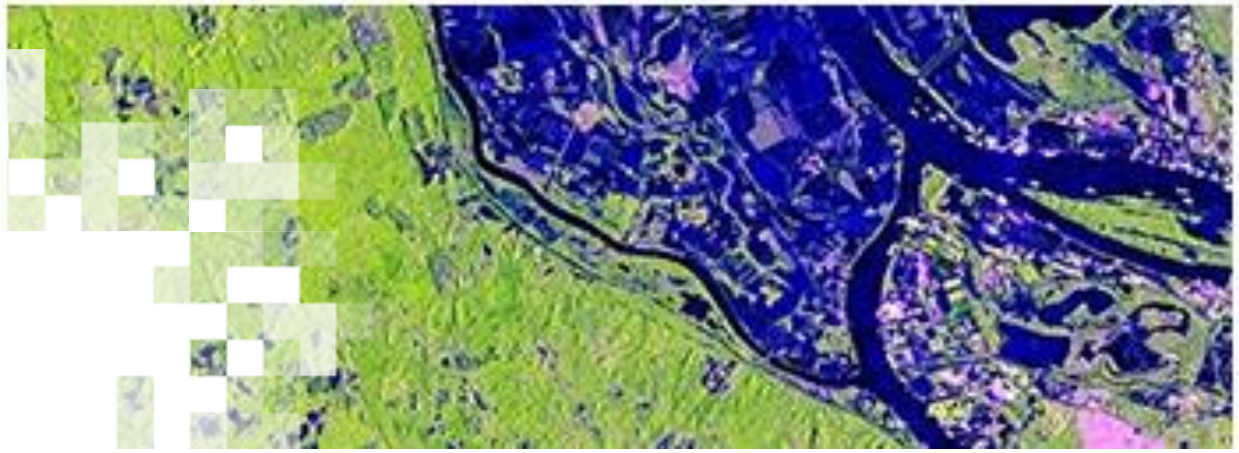
Image Credit: Shugart et al, 2010

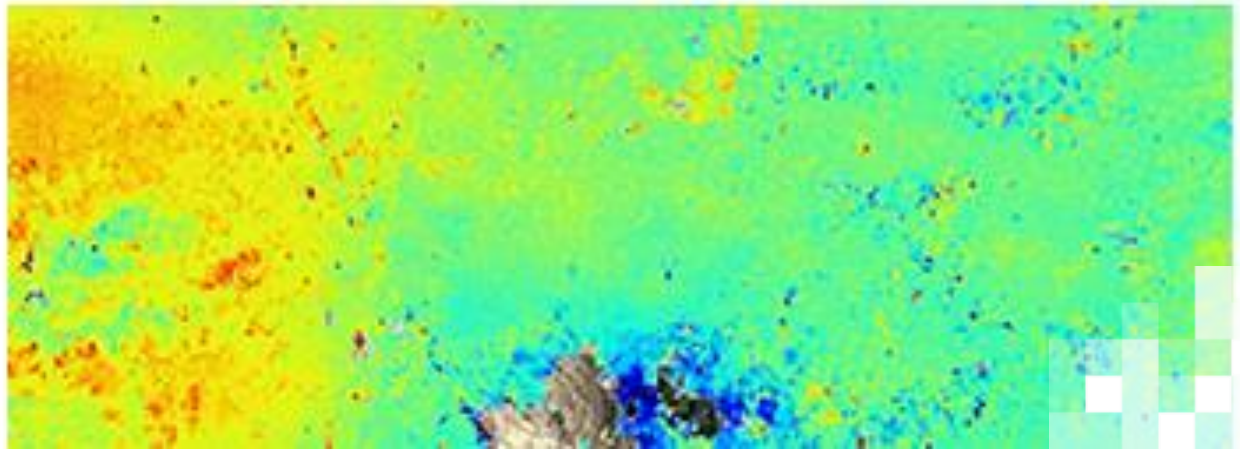
Surface Parameter: Dielectric Constant





- During the land surface freeze/thaw transition, there is a change in dielectric properties of the surface.
- This causes a notable increase in backscatter.



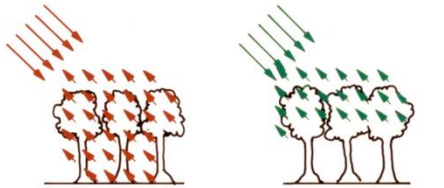


NISAR Early Results: Science and Applications

NISAR Science Focus Areas

Solid Earth, Ecosystems, Cryosphere Science and Applications Mission

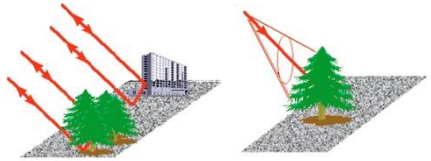
L- and S-band Wavelength



L- longer 24 cm

S- shorter 9 cm

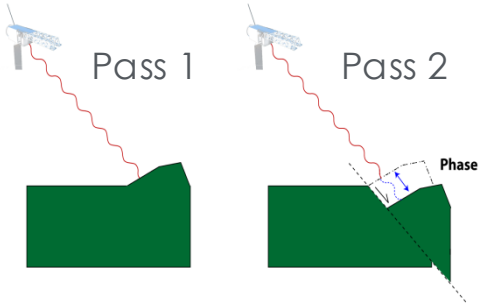
Polarimetry



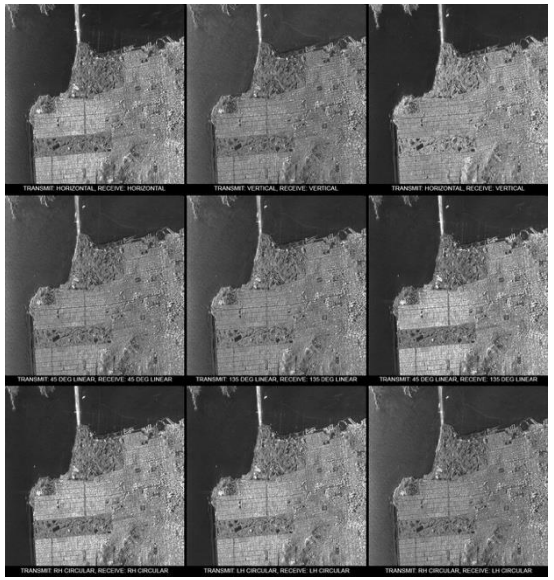
Oriented Structures

Random Volumes

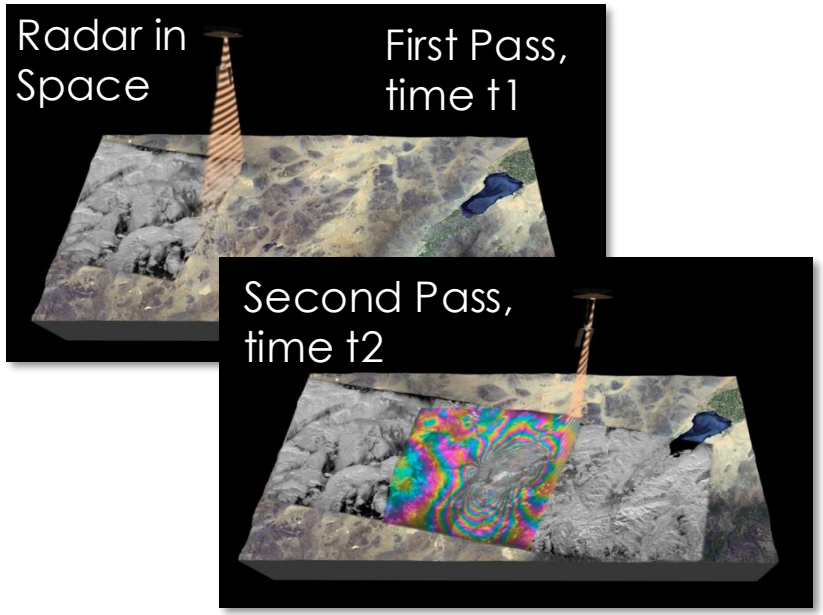
Repeat Pass InSAR



Polarimetric Diversity

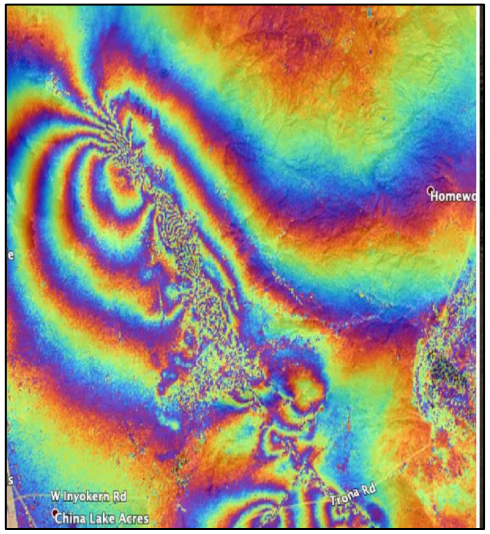


Repeat Pass Interferometry

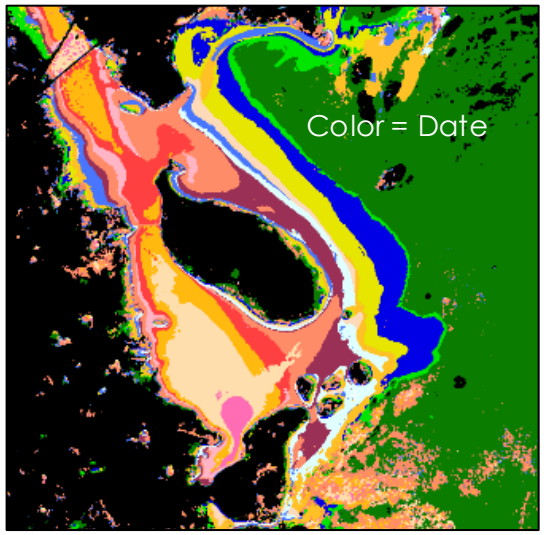


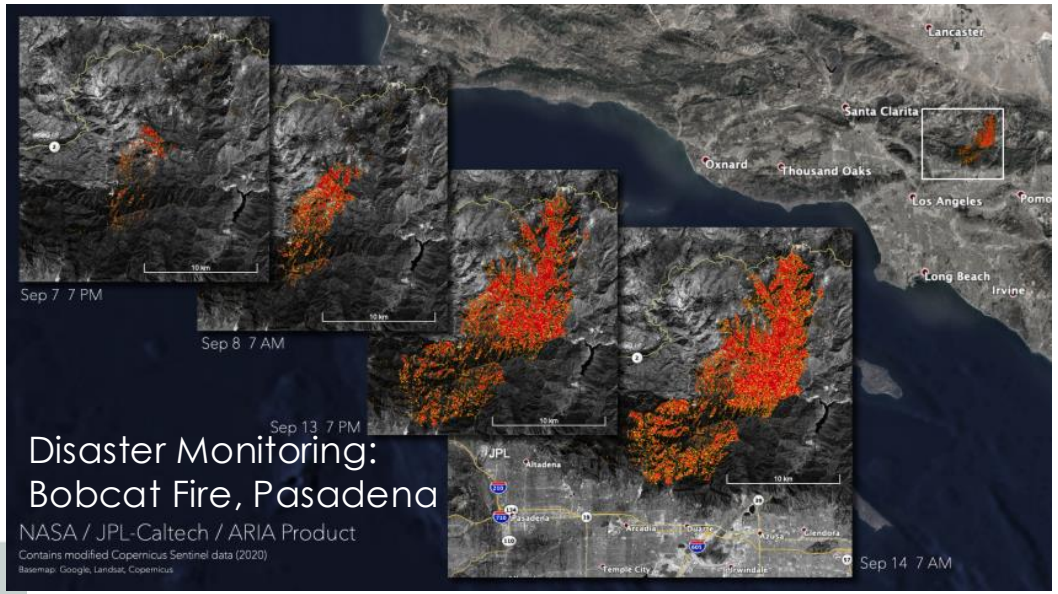
NISAR Science

Earthquake Dynamics, CA



Wetland Inundation, India





Key Scientific Objectives

Dynamics of Ice: Ice sheets, Glaciers, and Sea Level

- Understand the response of ice sheets and glaciers to climate change and the interaction of sea ice and climate

Ecosystems and Biomass Change

- Understand the dynamics of carbon storage and uptake in wooded, agricultural, wetland, and permafrost systems

Solid Earth Deformation: Hazard Response

- Improve knowledge for forecasts of earthquakes, volcanic eruptions, and landslides

Coastal Processes: India

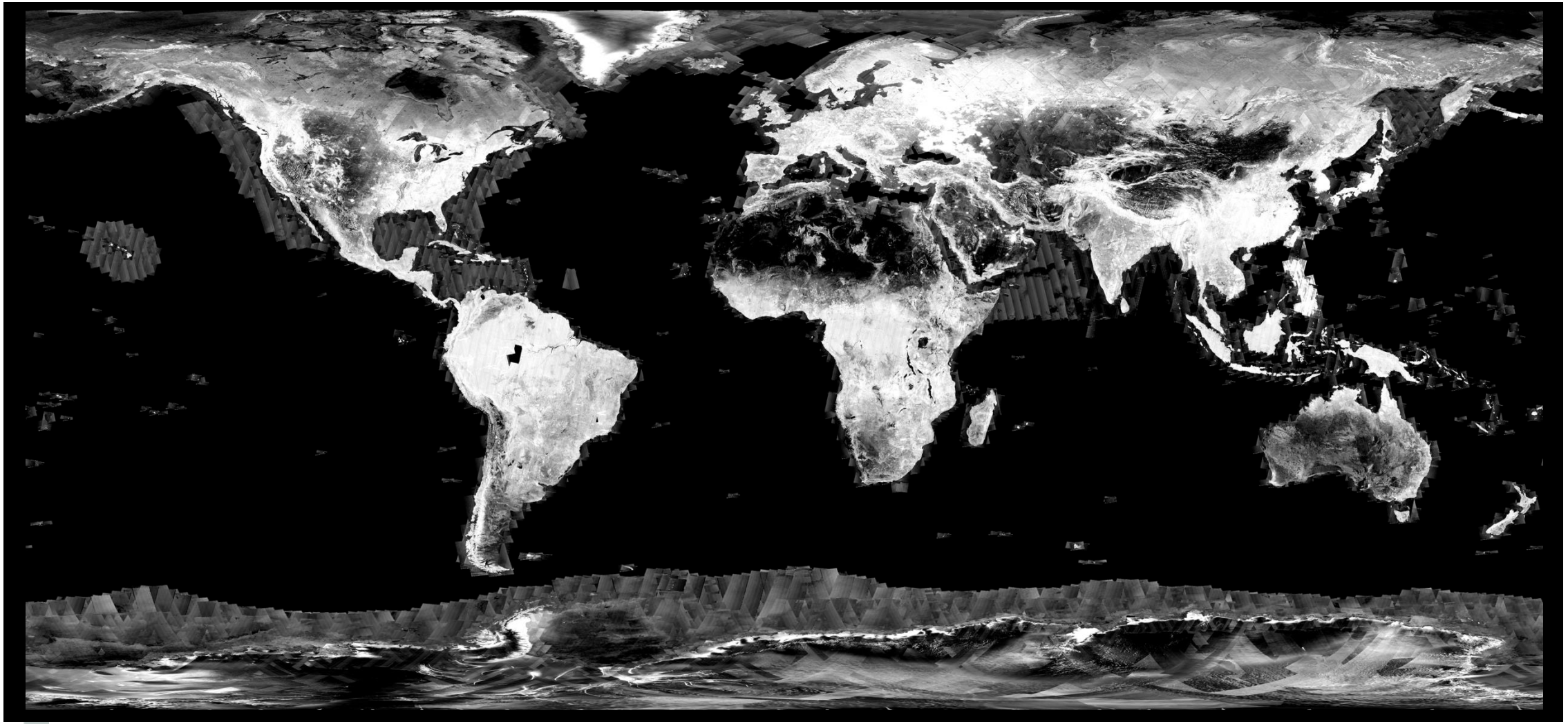
- Understand the state of important mangroves
- Understand how coastlines are changing around India
- Determine shallow bathymetry around India
- Assess variation of winds in India's coastal waters

Key Applications Objectives

- Understand societal impacts of dynamics of water, hydrocarbon, and sequestered CO_2 reservoirs
- Enhance agricultural monitoring capability in support of food security objectives
- Apply NISAR's unique data sets to explore the potentials for urgent response and hazard mitigation

NISAR Global Mosaic

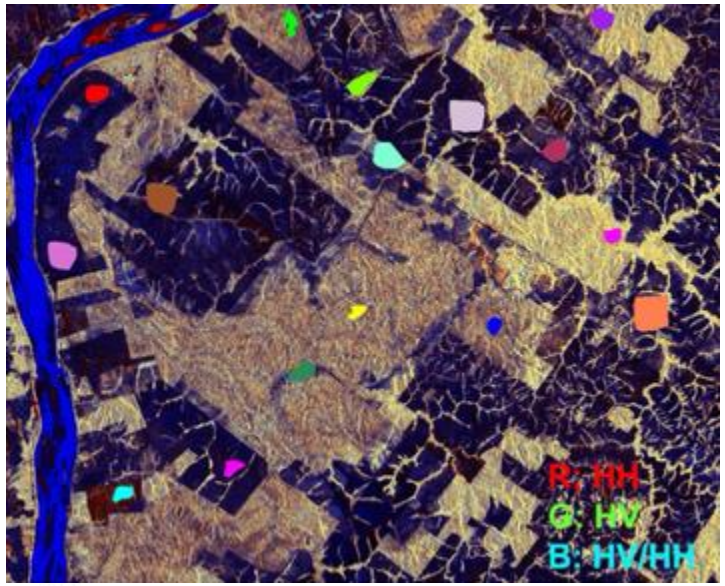
HH, 12-Day Cycle Mosaic of Earth's Land and Ice Surfaces

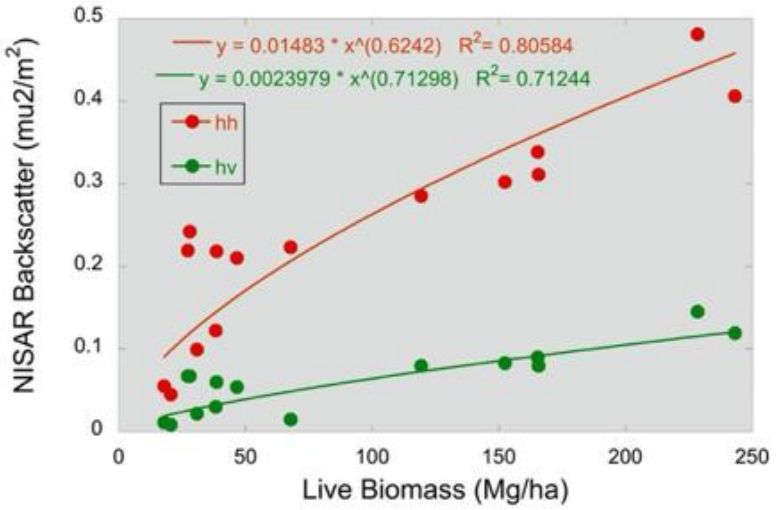


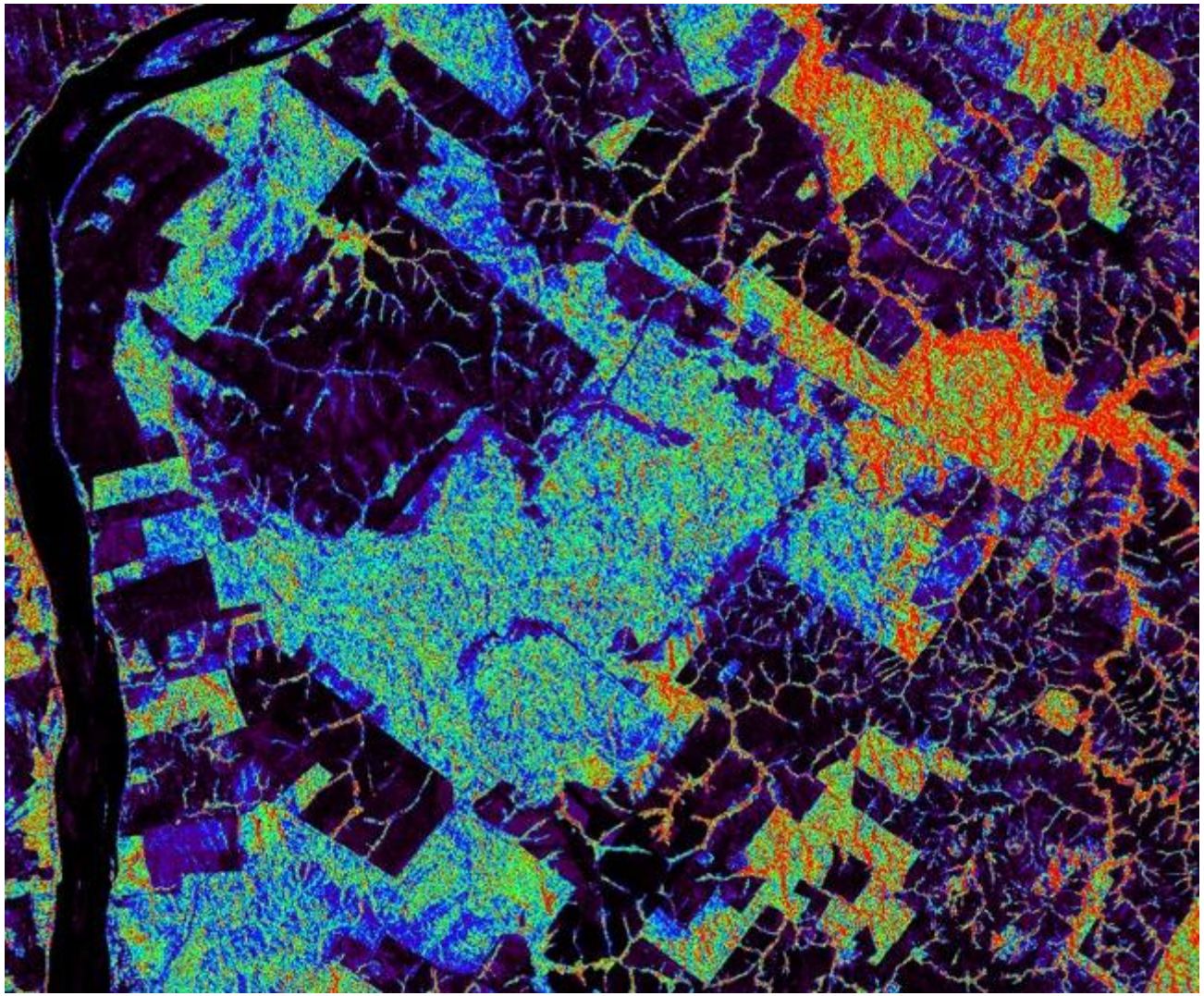
Pre-Release Mosaic Produced by G. Shiroma, JPL, from Standard GCOV Product

Ecosystems: Above Ground Biomass

Tocantins, Brazil



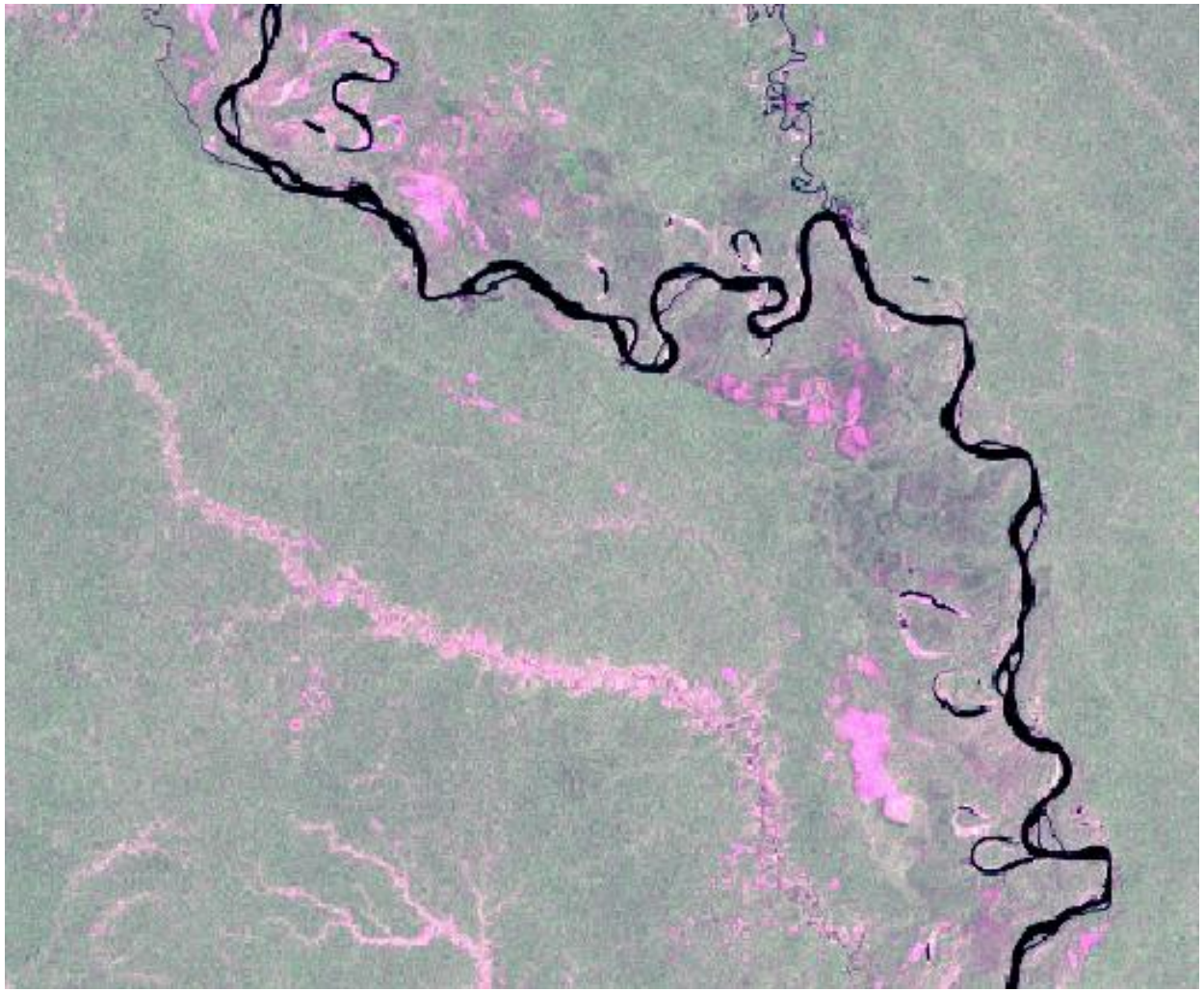




Courtesy of S. Saatchi

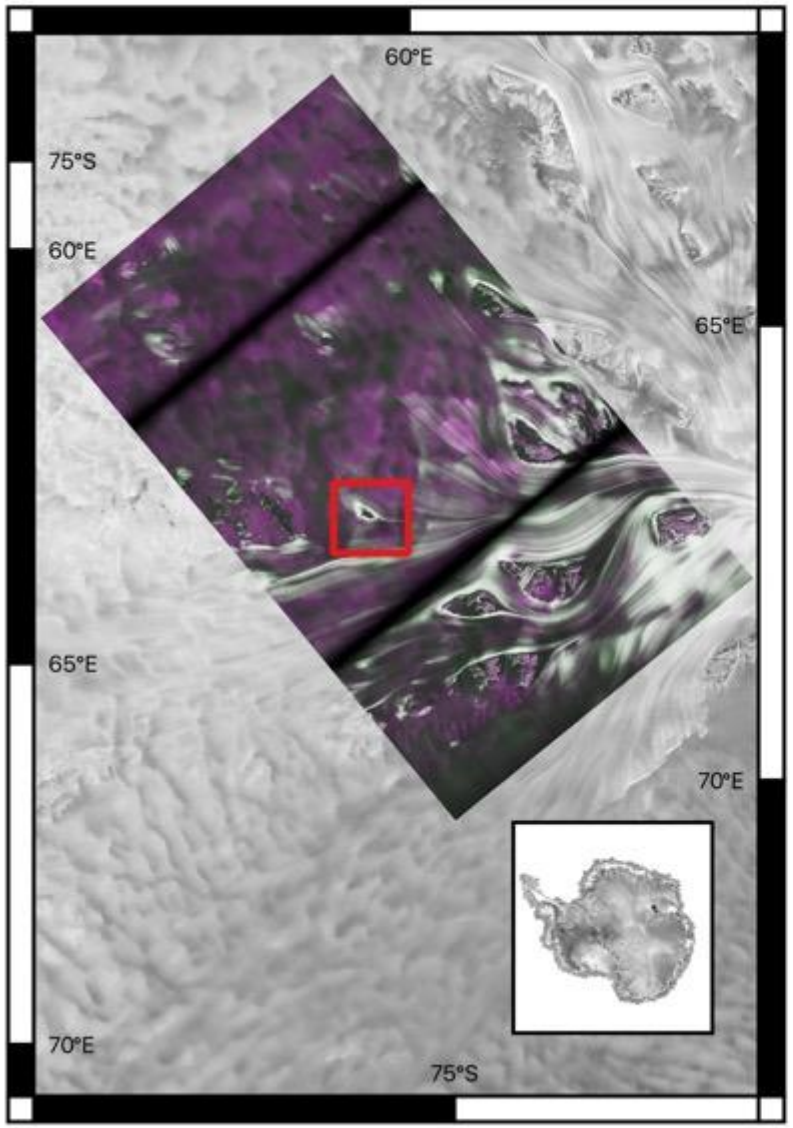
Ecosystems: Wetland Inundation

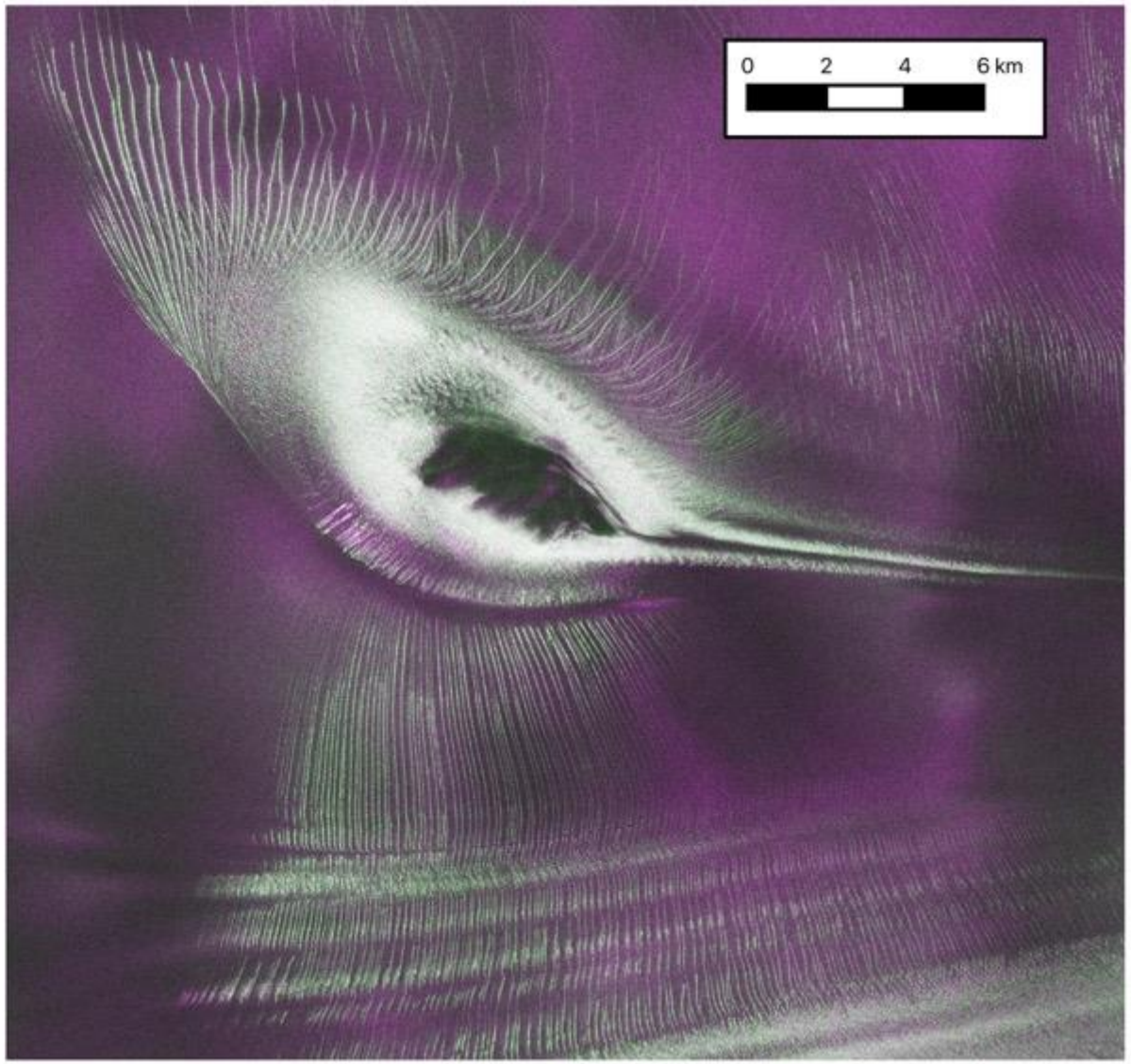
NISAR GCOV (L-Band)



Courtesy of M. Lavalle, JPL

Cryosphere: Dual-Polarimetric Backscatter in Antarctica





Left: NISAR L-band image of the Fisher–Mellor–Lambert glaciers flowing to the Amery Ice Shelf. Flow stripes, bedrock outcrops, and crevasses are visible in HH (magenta) and HV (green).

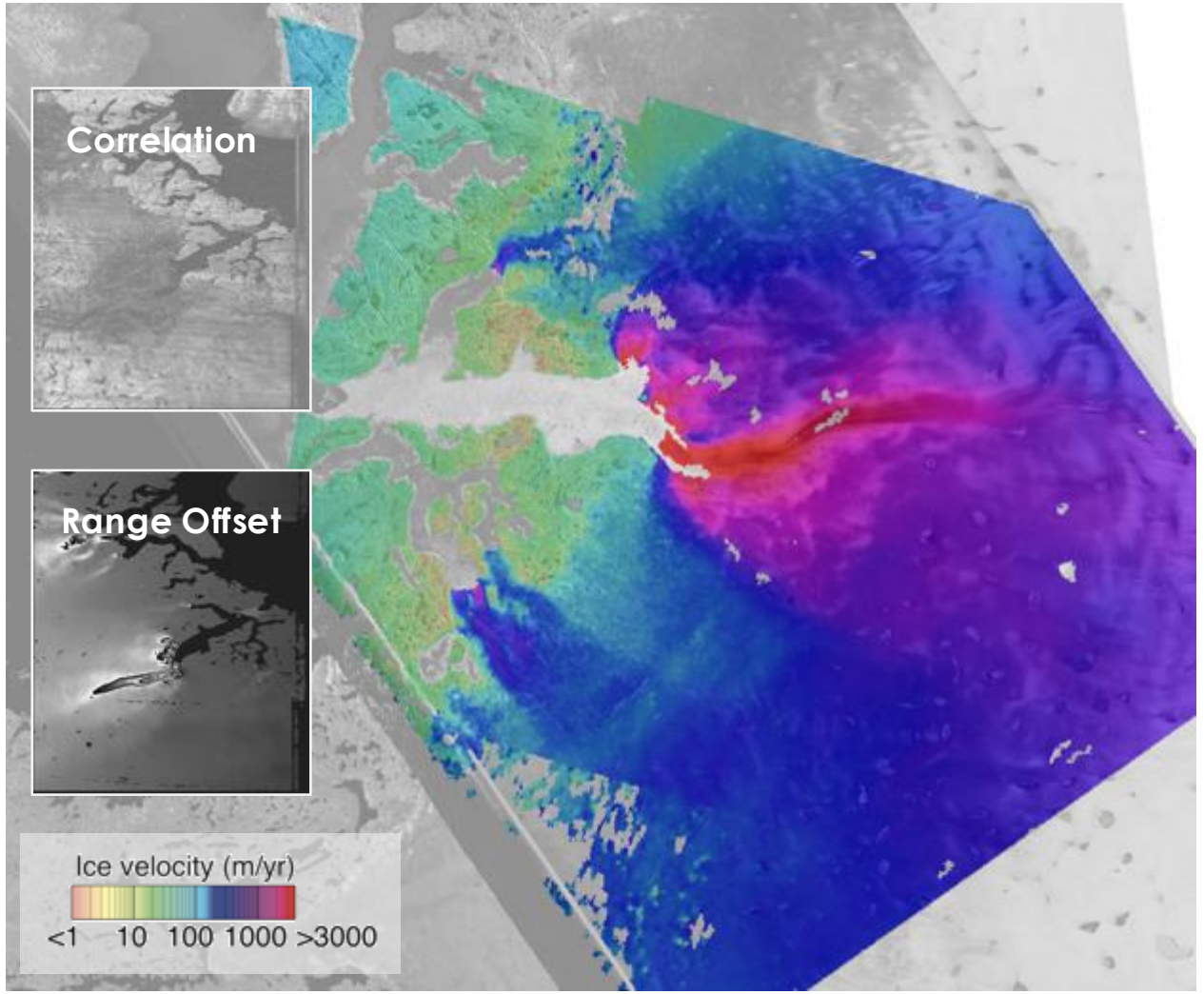
Right: Close-up of Nunatak Zaterjavshijsja and surrounding active ice stream, highlighting intense crevassing and surface deformation

Courtesy of S. Jeong

Cryosphere: Ice Sheet Velocity

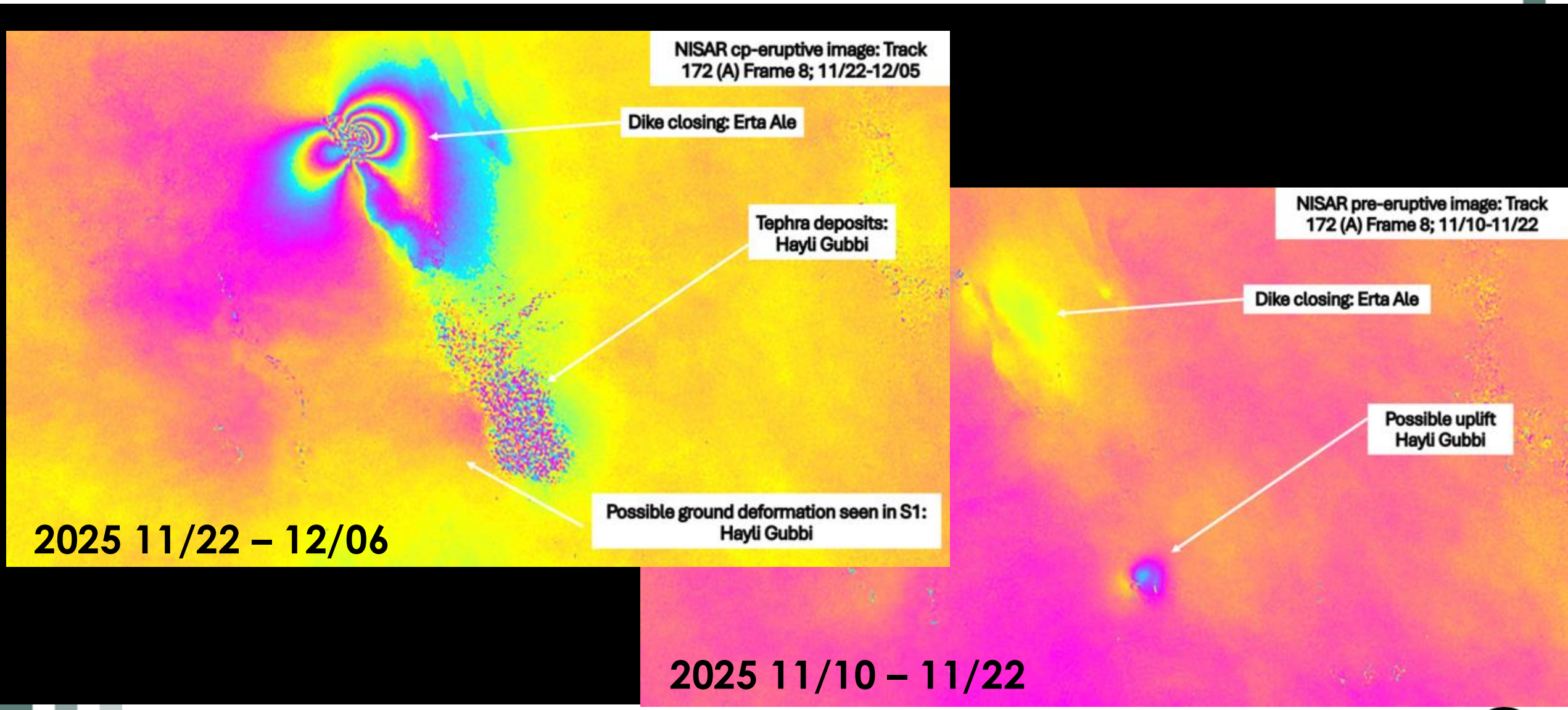
L-Band Backscatter (γ^0) over Jakobshavn Glacier (Greenland)

Ice Velocity Solution with NISAR and Sentinel-1 Range Offsets



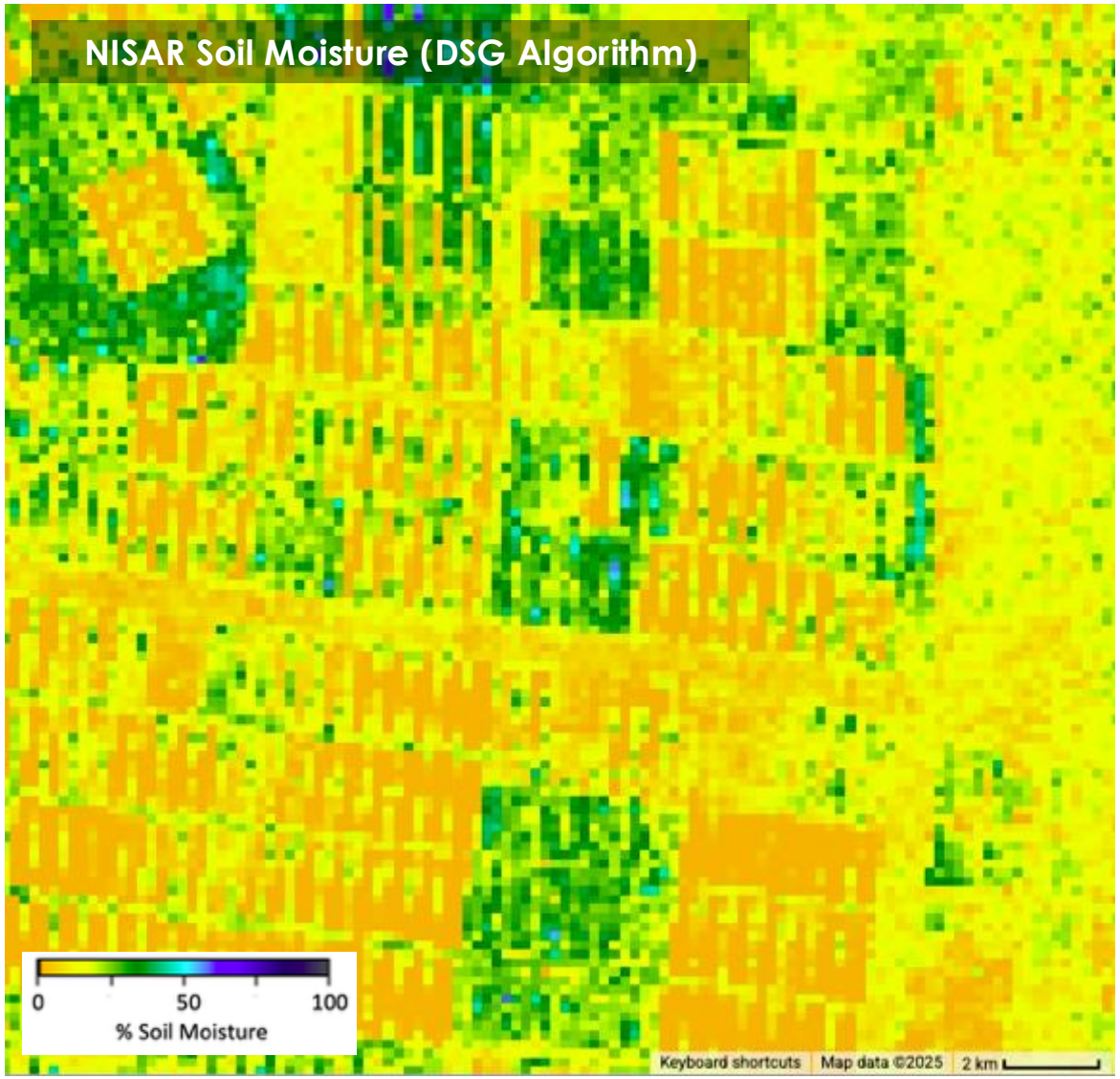
Courtesy of I. Joughin

Solid Earth: Hayli Gubbi Eruption (Ethiopia)



Credit: Matt Pritchard , Cornell Univ.

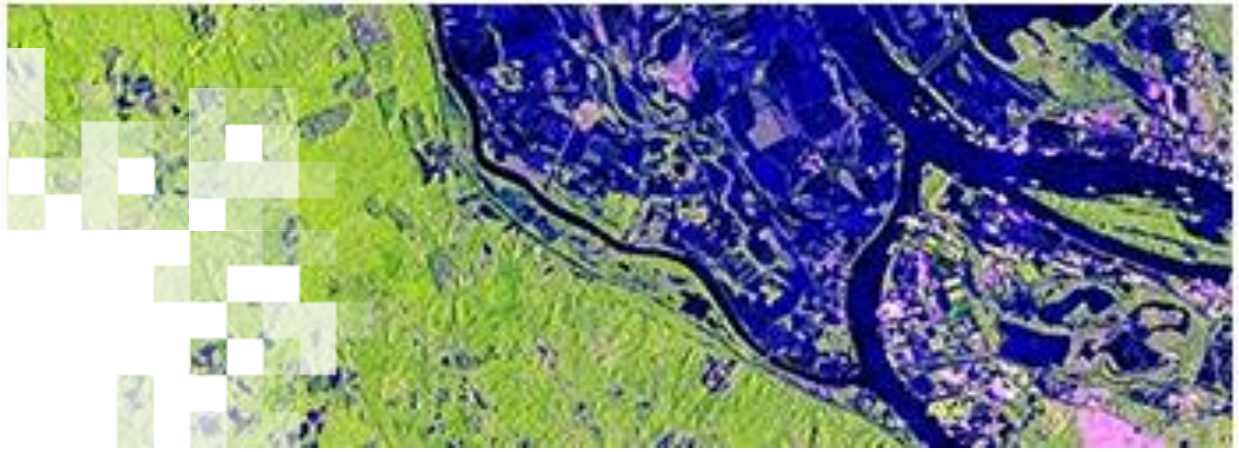
Soil Moisture

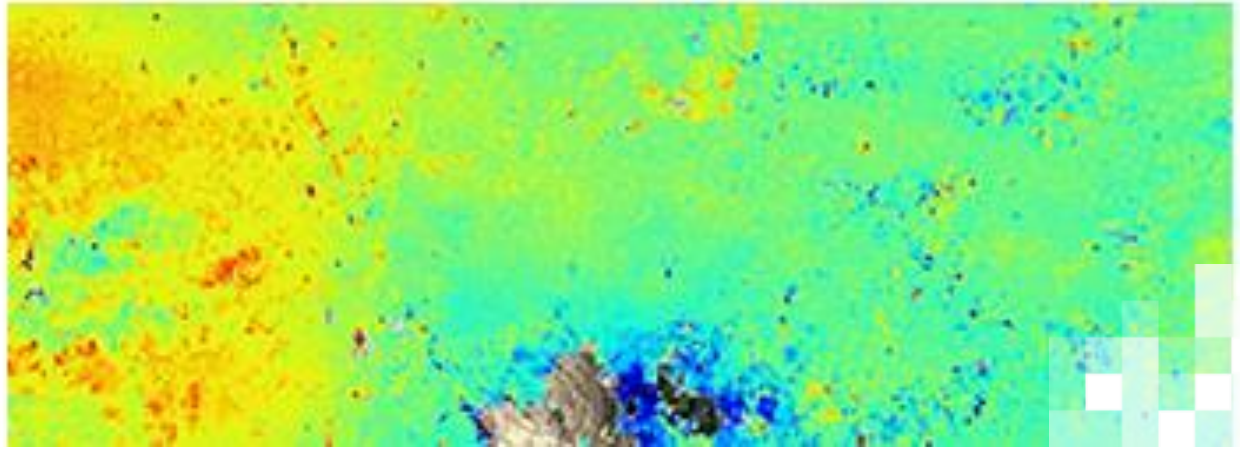


Courtesy of R. Lohman

Applications

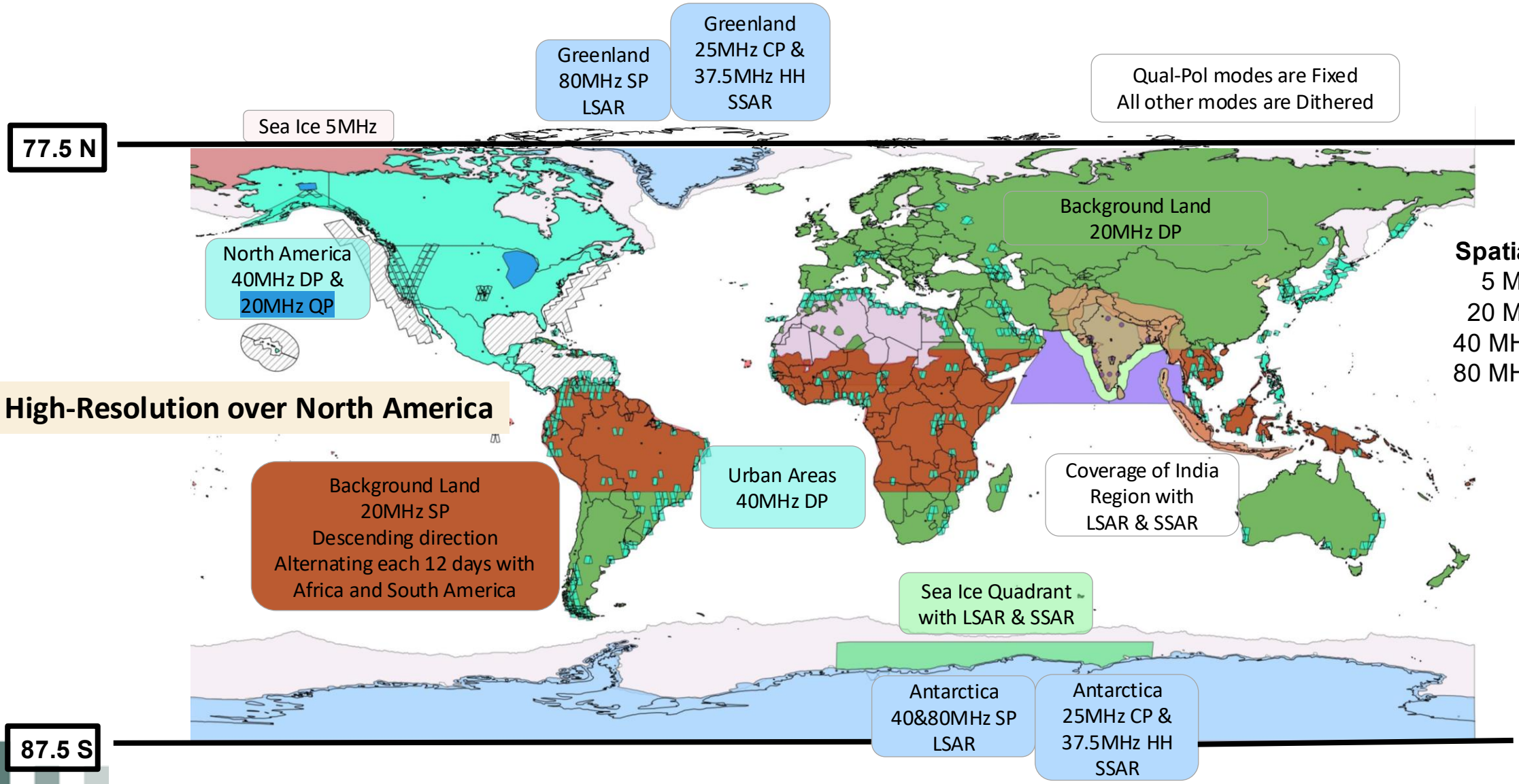
https://science.nasa.gov/mission/nisar/societal-benefits/





NISAR Observation Plan and Data

Current Observation Plan



Spatial Resolution

5 MHz ~ 30 x 6 m
20 MHz ~ 7.5 x 6 m
40 MHz ~ 3.75 x 6 m
80 MHz ~ 1.95 x 6 m

SP – Single Pol
DP – Dual Pol
QP – Quad Pol
CP – Cross Pol

Accessed via: https://experience.arcgis.com/experience/6052a864cd01459393884a7f751558e3

NISAR Data Levels

Data Product	Description
Level 0	Raw telemetry and signal data.
Level 1	Data are provided in satellite coordinates (range-Doppler) rather than geographic coordinates.
Level 2	Data are geocoded onto a map grid (UTM or polar stereographic projection) and can be directly overlaid on a map or combined with other geocoded data.
Level 3	Data are geocoded, derived science products expressed in physical units. The only global Level 3 product generated by NISAR is soil moisture. There are algorithms (ATBD's) to generate discipline-specific Level 3 products, and these have been validated over calibration/validation sites. These are biomass, vegetation disturbance, wetlands inundation, crop area, surface deformation, damage proxy, ice sheet/glacier velocity, sea ice velocity.

NISAR L-Band Data

Products	Product Level	Extent
RSLC (Range Doppler Single Look Complex)	L1	Global
GSLC (Geocoded SLC)	L2	Global
GCOV (Geocoded Covariance)	L2	Global
GUNW (Geocoded Unwrapped and wrapped Interferogram)	L2	Global
GOFF (Geocoded Pixel Offsets)	L2	Cryosphere Regions
RIFG (Range-Doppler wrapped Interferogram)	L1	Cryosphere Regions
RUNW (Range-Doppler Unwrapped Interferogram)	L1	Cryosphere Regions
ROFF (Range-Doppler Pixel Offsets)	L1	Cryosphere Regions
Soil Moisture	L3	Near Global

NISAR Data Status

Feb 2026: Pre-Calibration Products

- A large number of pre-calibrated global data products were made available on February 27, 2026. This release included over 100,000 Level 1-3 products totaling over 500 TB of science data.

Jul 2026: Calibrated Forward Processing

- After the calibration phase concludes and planned software improvements are completed, the NISAR project will begin forward processing of newly-acquired data. Forward processing is targeted to begin in July 2026.
- Fully-calibrated Level 0-3 products will be continuously generated from all data acquired from the start of forward processing into the future.
- New data will be continuously published to ASF and made publicly available. Level 1-3 products will have a nominal latency of 36-72 hours from data acquisition to availability.

Late 2026: Calibrated Back Processing

- After the start of forward processing, the NISAR project will produce calibrated Level 0-3 products from the global backlog of all data collected September 23, 2025 through the start of forward processing in July 2026. This processing will complete before the end of the calendar year.

NISAR Data Access

Map-Based Search and Discovery:

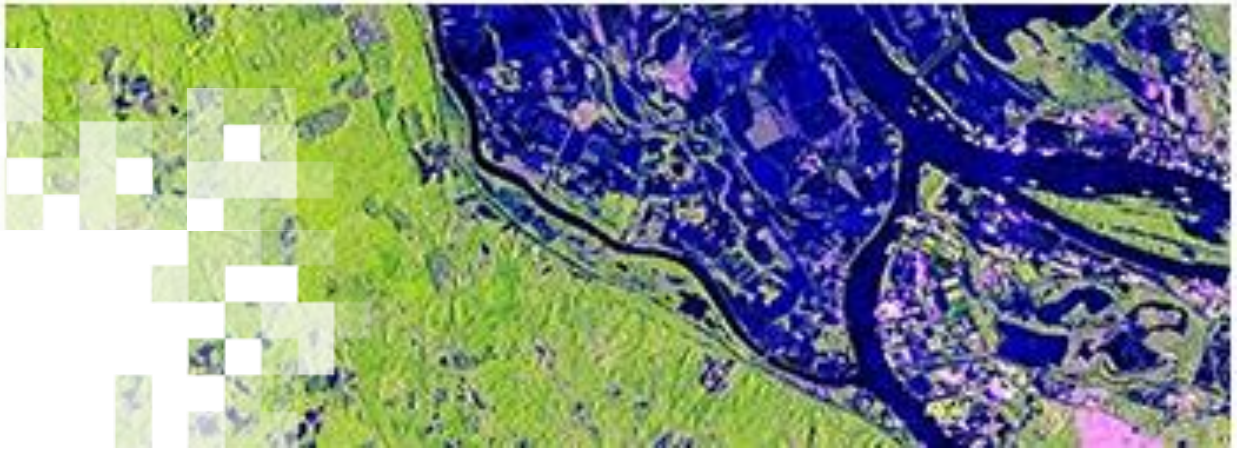
- Earthdata Search
- ASF Vertex
- Bhoonidhi (for access to ISRO L- and S-Band data)

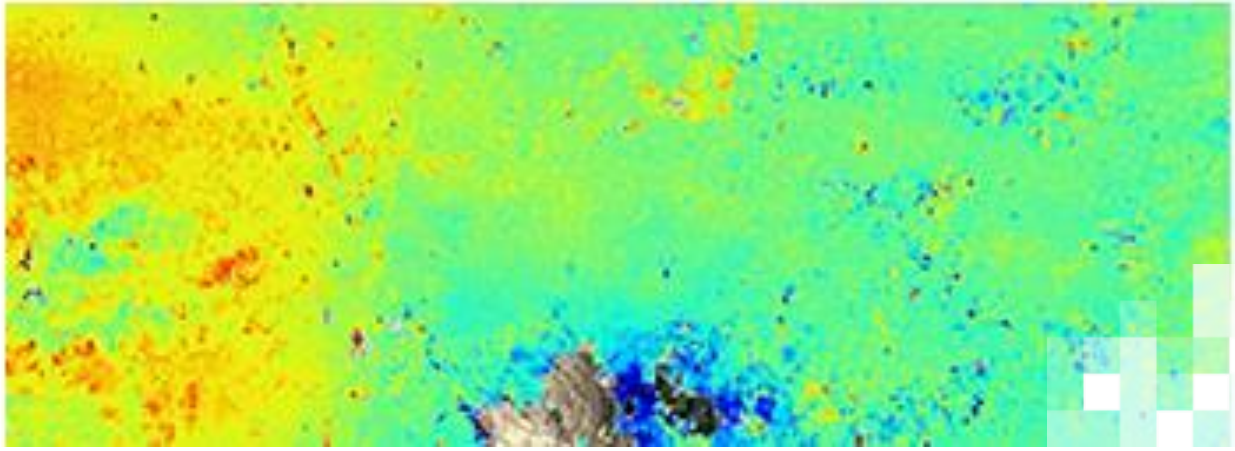
Programmatic Search and Discovery:

- earthaccess
- asf-search

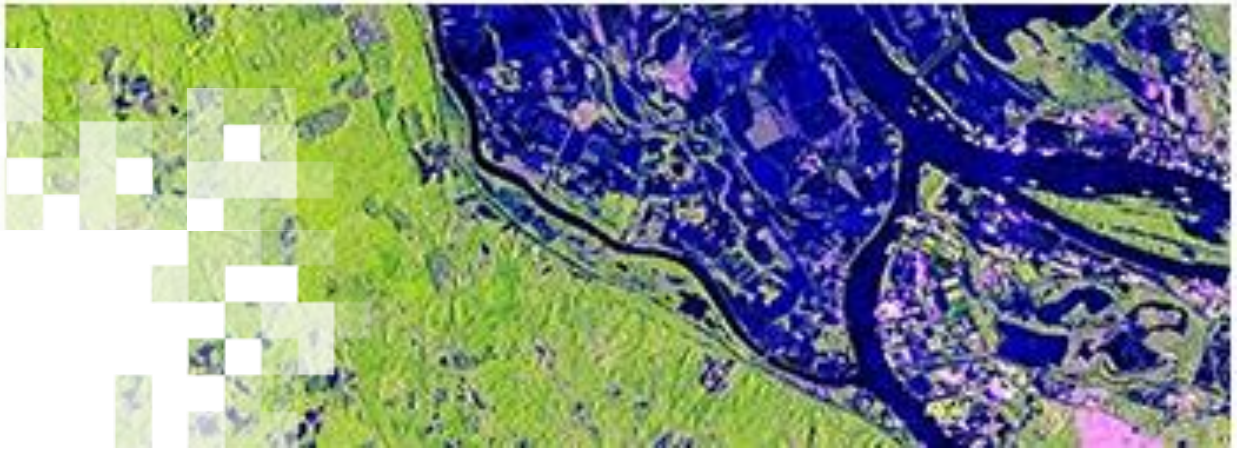
AWS S3 Direct Bucket Access

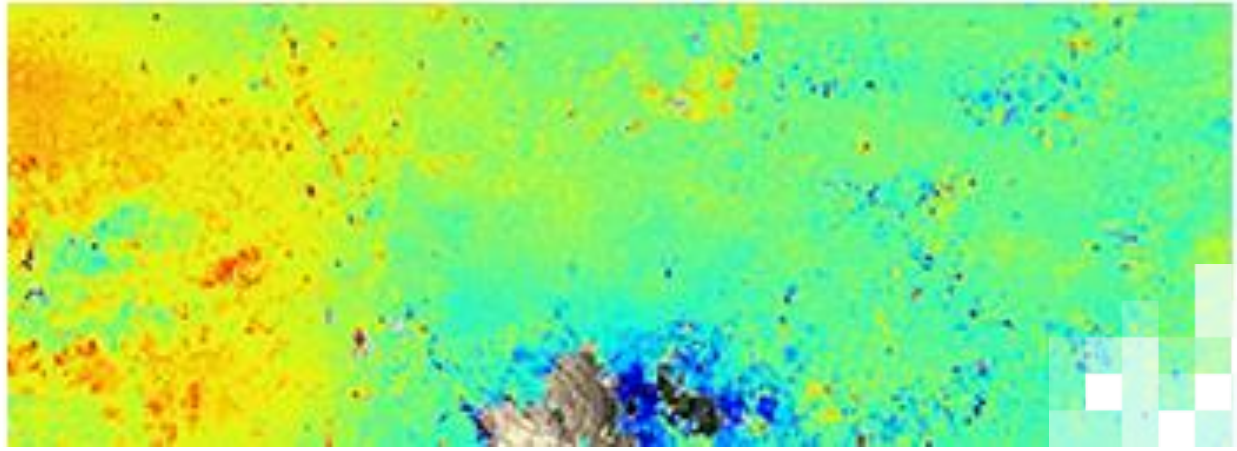
nisar-docs.asf.alaska.edu/access-overview/





Demonstration





Summary

Summary

- NISAR is designed to monitor continuous Earth surface changes (centimeter-to-meter scale) globally, day and night, and through almost all weather/cloud conditions. Key focus processes include tectonic deformation, ice sheet motion, ecosystem change, and agricultural monitoring.
- NISAR has an L-band (24 cm wavelength) and an S-band (9.4 cm wavelength) radar. The satellite has an exact 12-day repeat cycle, an imaging swath greater than 240 km using the SweepSAR technique, and spatial resolutions varying between 3 and 30 meters depending on the radar mode.
- Polarization acquisitions vary depending on acquisition mode.
- Core science disciplines cover the Cryosphere (glacier/ice sheet/sea ice), Ecosystems (agriculture, biomass, wetlands, forest degradation) and Solid Earth (hazards like earthquakes, volcanoes, and landslides).
- NISAR can address different applications and support disaster and hazard management.
- NISAR data products are openly and freely available. L-band data is available through the ASF DAAC and S-band (along with coincident L-band data) are available through ISRO's Bhoonidhi platform.

Summary (Cont.)

- Data processing levels span from Level 0 (raw data) to Level 3 (geocoded derived products, with soil moisture being the only L3 global product being generated.
- L1 and L2 products contain information about amplitude, phase, interferometric products, coherence, and pixel offsets.
- L1 products are in the satellite native coordinates (range-doppler) and L2 products are geocoded and analysis ready. The data are in HDF-5 format.
- **In July 2026** the fully calibrated forward processed data will be released with a data availability latency of 36–72 hours.
- **In late 2026** the back-processing of the archived global historical data backlog will be released.

Looking Ahead to Session 2

NISAR Data Access and Tools

- Identify where to access NISAR data
- Recognize the data format and tools for reading the data
- Apply tools for visualizing and analyzing NISAR data

Homework and Certificates

- **Homework:**
  - One homework assignment
  - Opens on Jul. 16, 2026
  - Access from the training webpage
  - Answers must be submitted via Google Forms
  - **Due by Aug. 6, 2026**

- **Certificate of Completion:**
  - Attend all three live webinars (attendance is recorded automatically)
  - Complete the homework assignment by the deadline

You will receive a certificate via email approximately two months after completion of the course.

Contact Information

Trainers:

- Erika Podest
  - erika.podest@jpl.nasa.gov

- ARSET Website
- ARSET YouTube

For questions, comments, or to share how you have applied our trainings to your work or studies, email nasa.arset@gmail.com.

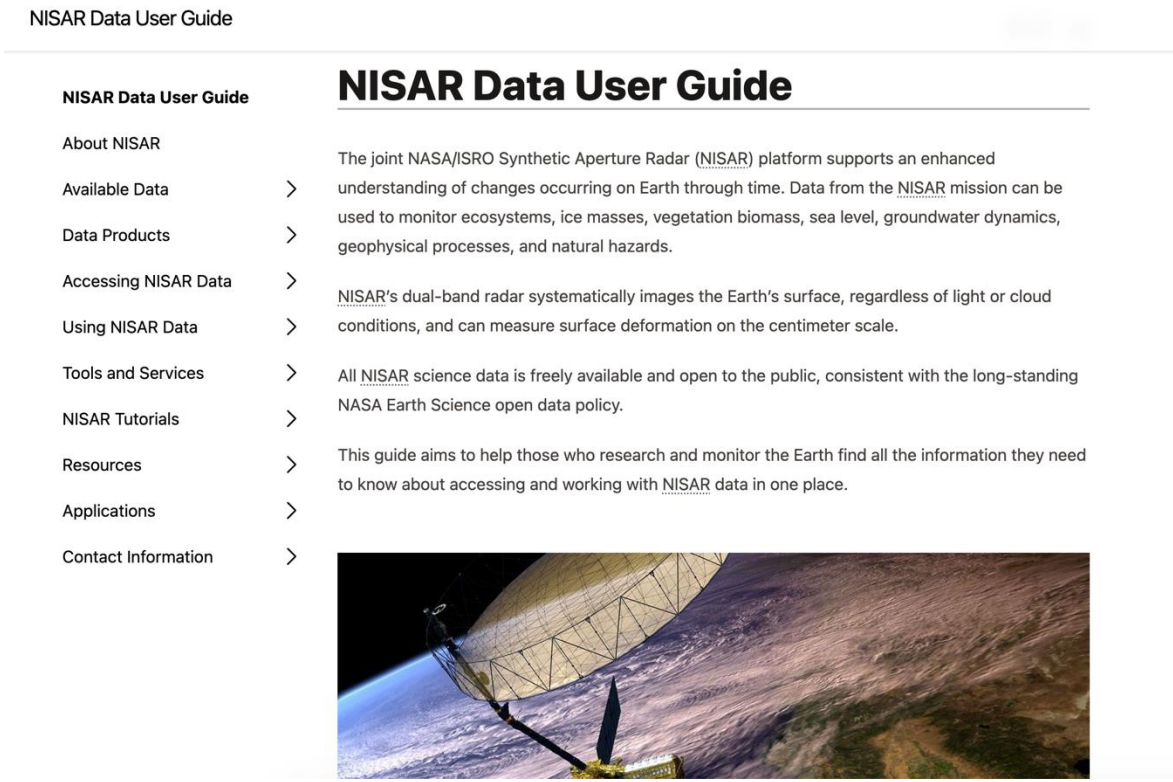
Join our mailing list to stay up-to-date on our latest trainings. Visit our Contact page to subscribe.

NISAR Resources

NISAR Handbook

NISAR Data User Guide

https://nisar-docs.asf.alaska.edu/

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TRAIN - EMPOWER - ADVANCE

Thank You!