



Jet Propulsion Laboratory
California Institute of Technology

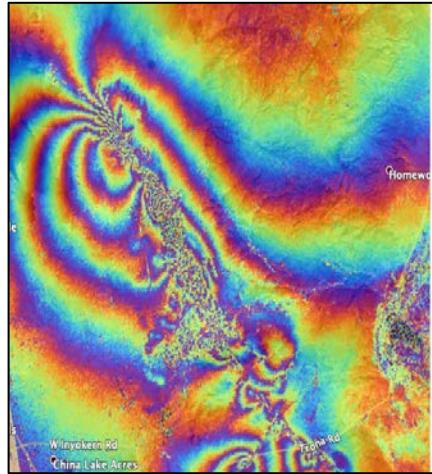
NASA-ISRO SAR (NISAR) Mission Overview

Paul A. Rosen

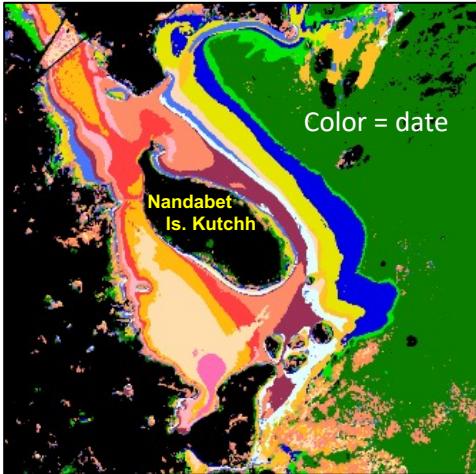
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NISAR Project Team

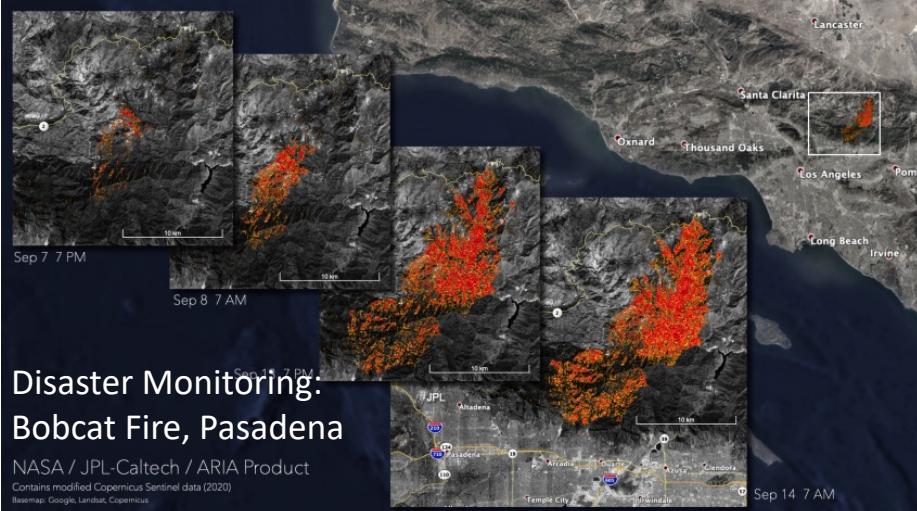
2022 UNAVCO ISCE+ Course
August 26 2022



Earthquake Dynamics,
Ridgecrest



Wetland Inundation, India



- **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: Hazard Response**

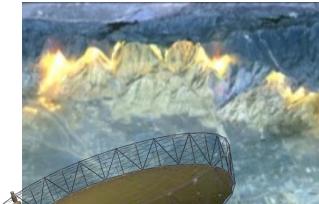
- Which major fault systems are nearing release of stress via strong earthquakes?
- Can we predict future eruptions of volcanoes?
- What are optimal remote sensing strategies to mitigate disasters and monitor/manage water and hydrocarbon extraction and use

- **Coastal Processes: India**

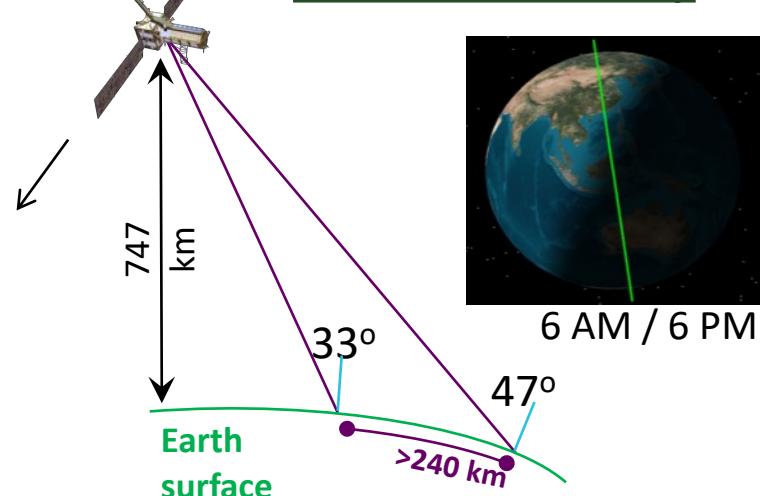
- What is the state of important mangroves?
- How are Indian coastlines changing?
- What is the shallow bathymetry around India?
- What is the variation of winds in India's coastal waters?

NISAR Characteristic:	Would Enable:
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 Will Uniquely Capture the Earth in Motion

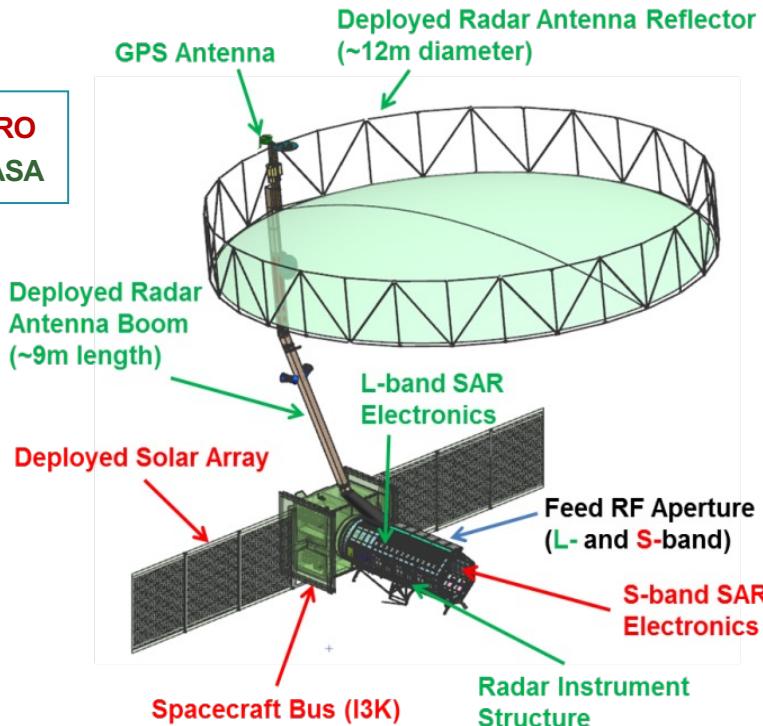


Observation Geometry





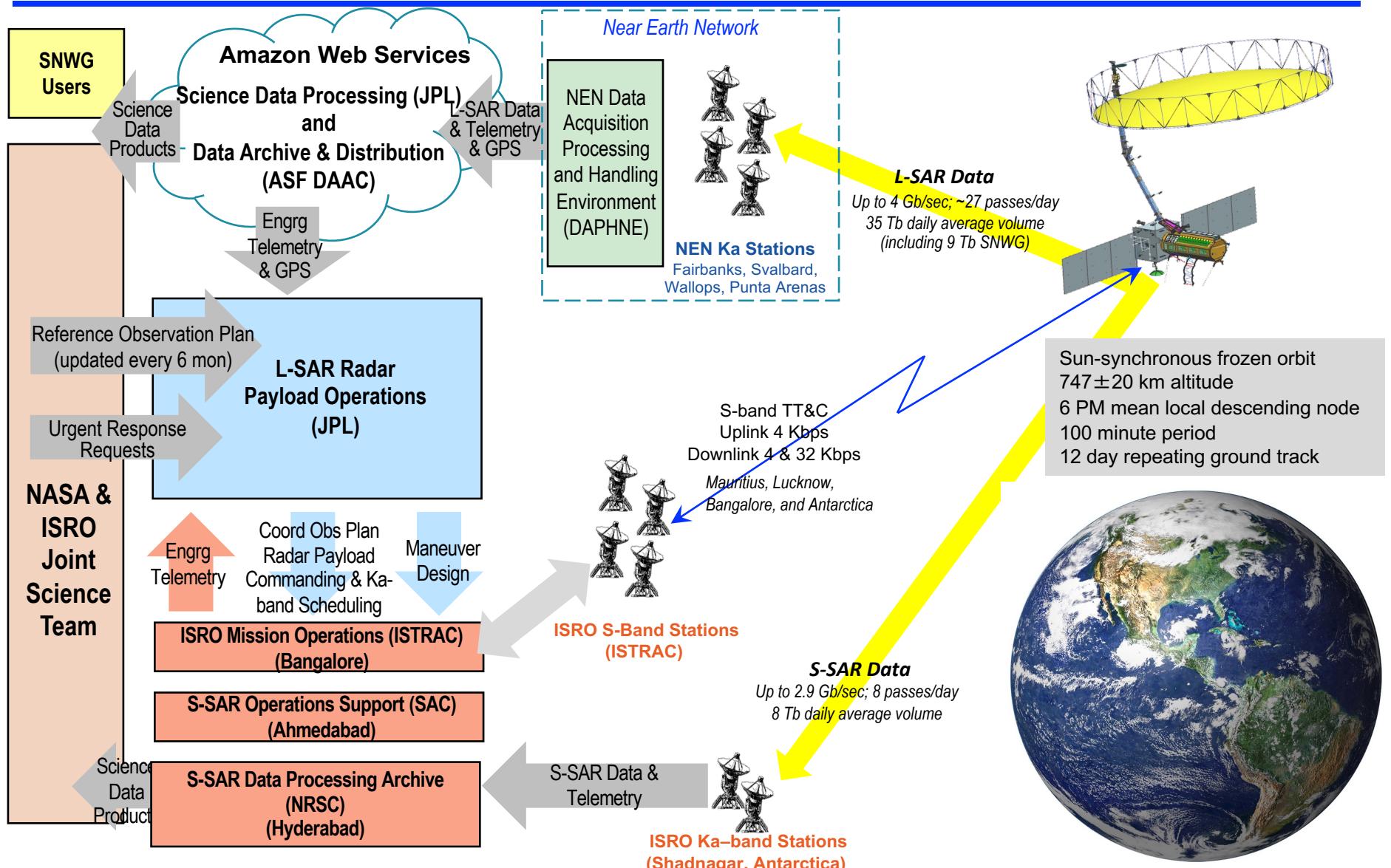
Close integration with international partner



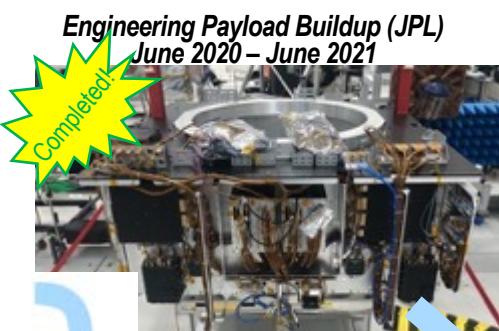
	Mass (kg)	Power (W)
Spacecraft Mainframe	920	1312
Engineering Payload	134	640
L-SAR	283	1515
S-SAR	314	2757
Common Instrument Structure	466	
Reflector and Boom	292	
Propellant	269	
Total	2678	6224

NASA Provides	ISRO Provides
<ul style="list-style-type: none"> • L-band SAR • Shared P/L structure & 12m reflector and boom 	<ul style="list-style-type: none"> • S-band SAR • S-SAR baseband data handling (BDH)
<ul style="list-style-type: none"> • Engineering payload <ul style="list-style-type: none"> - GPS, Power & Pyro - Payload Data System with 12 Tb recorder - NEN-compatible high rate Ka-band system 	<ul style="list-style-type: none"> • 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 NEN 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 Operations Overview



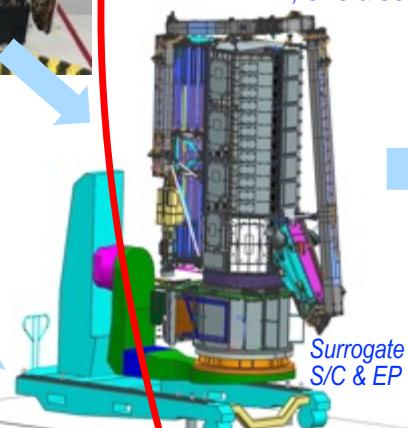
NISAR Development Status



SIT-2 & 3 (JPL)
Radar Payload I&T
Feb '21- Feb '23

We are Here

Radar Payload (with
BDH, GPS & SSR)



SIT-4 (URSC)
Observatory I&T
Mar '23-Jan '24



Launch Operations
(SHAR) & Launch
Jan 2024



March '21

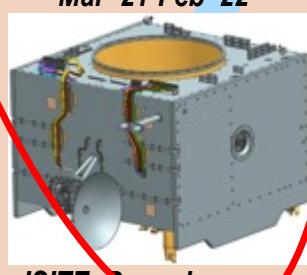
August '21



S-SAR I&T (SAC)



Baseband Data
Handler (BDH) (URSC)



ISITE, Bangalore

Satellite
Integration & Test
Establishment
(ISITE)
Bangalore

Geosynchronous
Launch Vehicle
(GSLV) Mark II

Satish Dhawan
Space Centre

Sriharikota

Boom/Reflector Integration

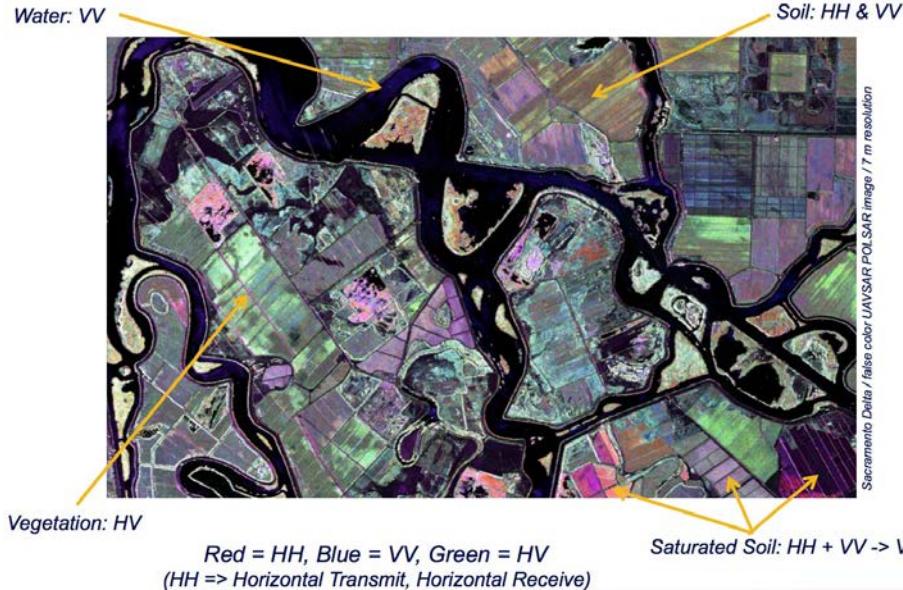


Flight Boom & Reflector were previously integrated & environmentally tested on flight spare structure in 2020



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

Versatility of SAR: Many Applications

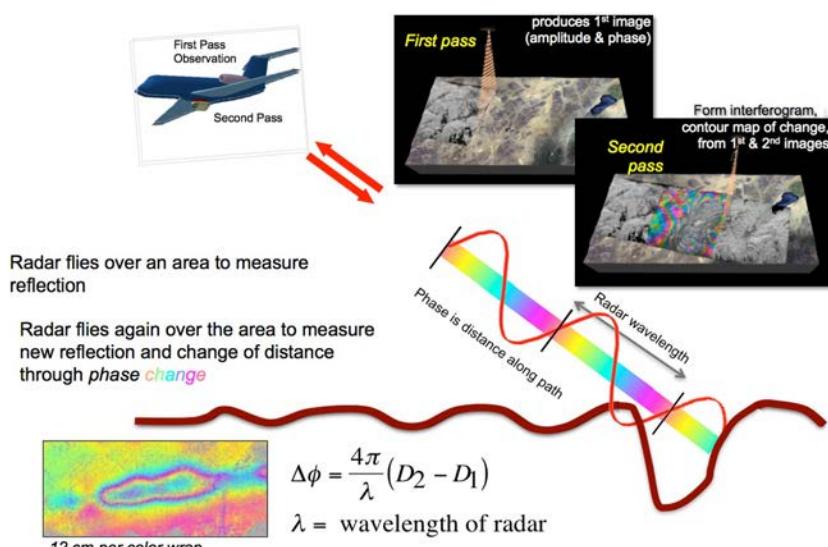


Polarimetric SAR

Use of polarization to determine surface properties

Applications:

- Flood extent (w/ & w/o vegetation)
- Land loss/gain
- Coastal bathymetry
- Biomass, disturbance
- Vegetation type, status
- Pollution & pollution impact (water, coastal land)
- Water flow in some deltaic islands



Interferometric SAR

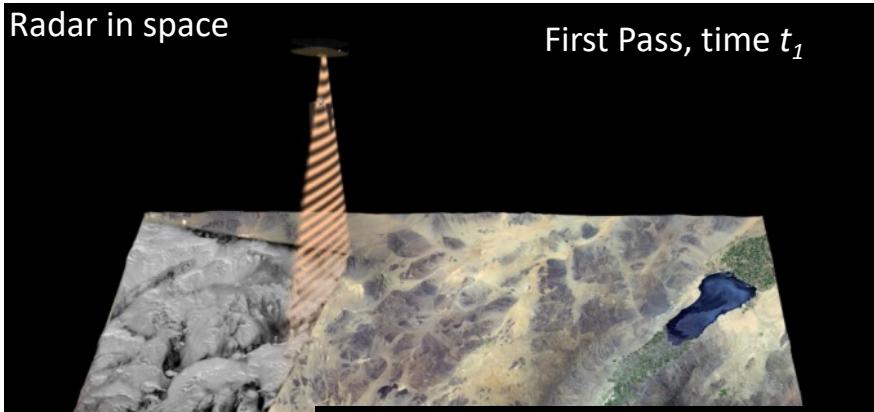
Use of phase change to determine surface displacement

Applications:

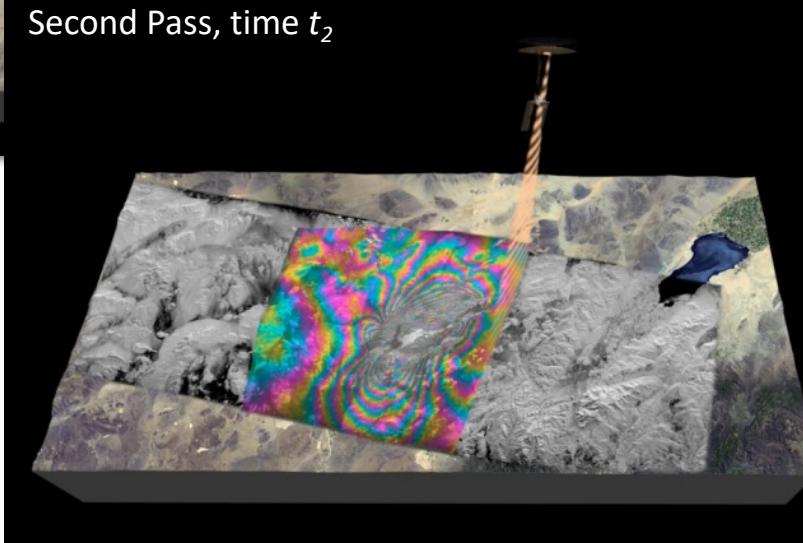
- Geophysical modeling
- Subsidence due to fluid withdrawal
- Inundation (w/vegetation)
- Change in flood extent
- Water flow through wetlands

Repeat Pass Interferometry

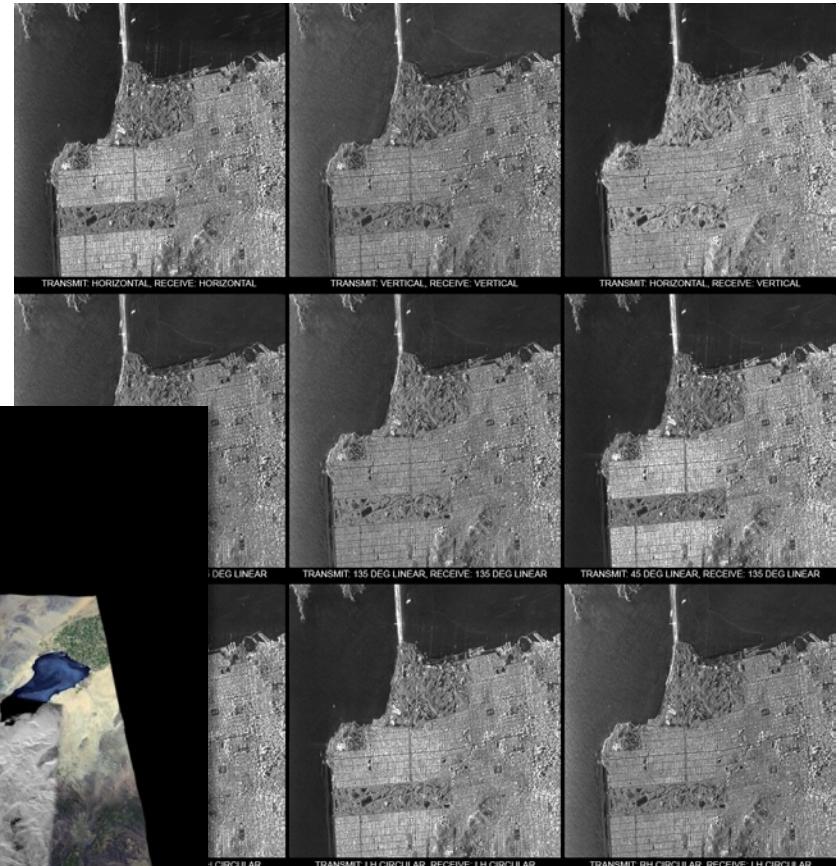
Radar in space



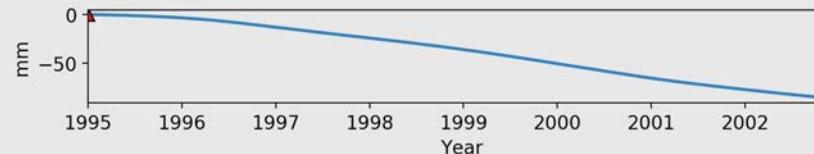
Second Pass, time t_2



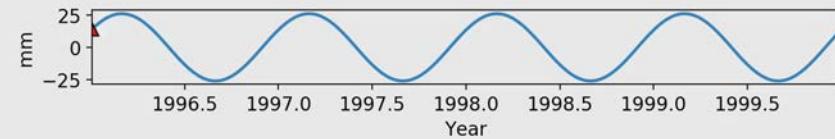
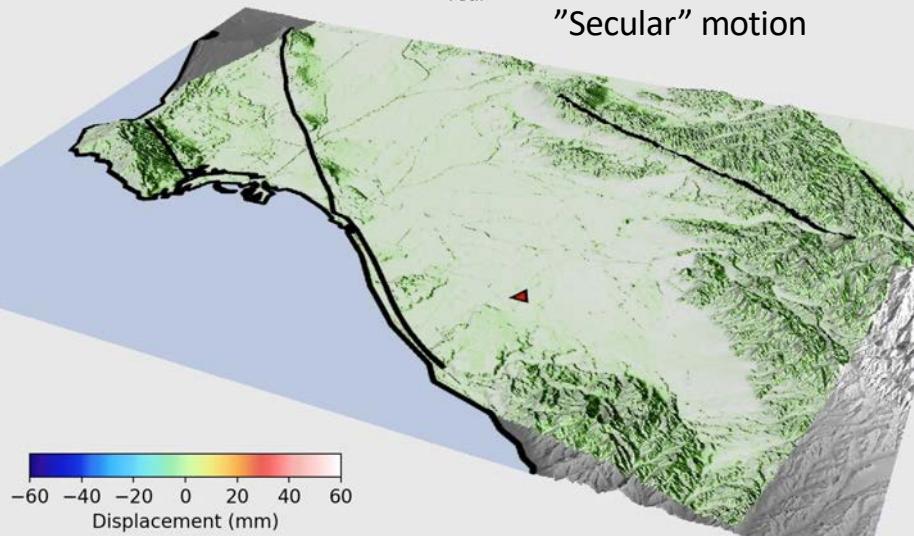
Polarimetric Diversity



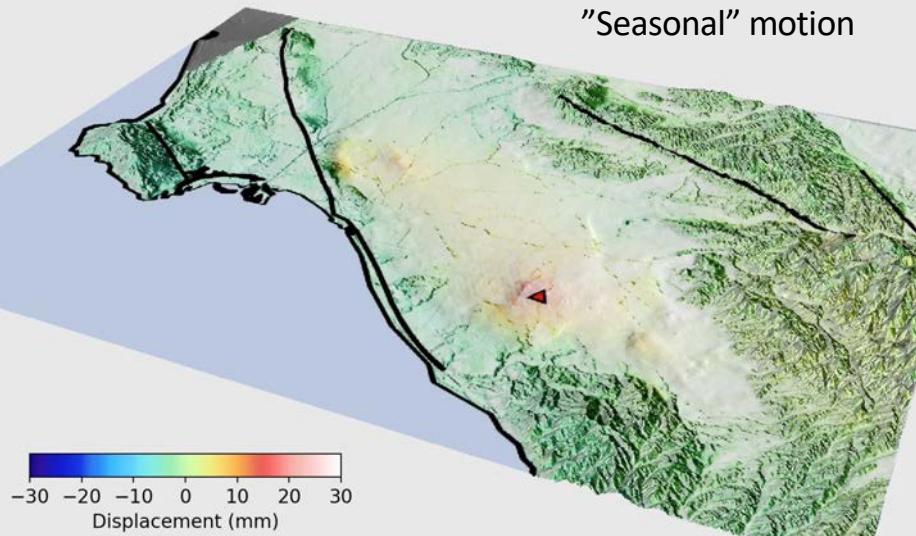
Earth's Dynamic Subsurface



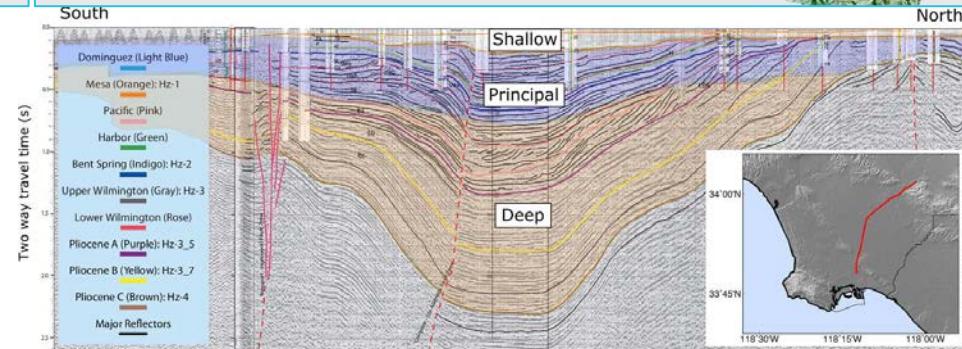
"Secular" motion



"Seasonal" motion



- Data → 18-year time series (881 igrams) + GPS + Hydraulic head from observation wells + geologic structure model
- Spatial pattern of seasonal ground deformation near the center of the basin corresponds to a diffusion process with peak deformation occurring at locations with highest groundwater production.
- Seasonal ground deformation associated with shallow aquifers used for the majority of groundwater production
- Long-term ground deformation over broader areas - correlated with delayed compaction of deeper aquifers and potential compressible clay layers.

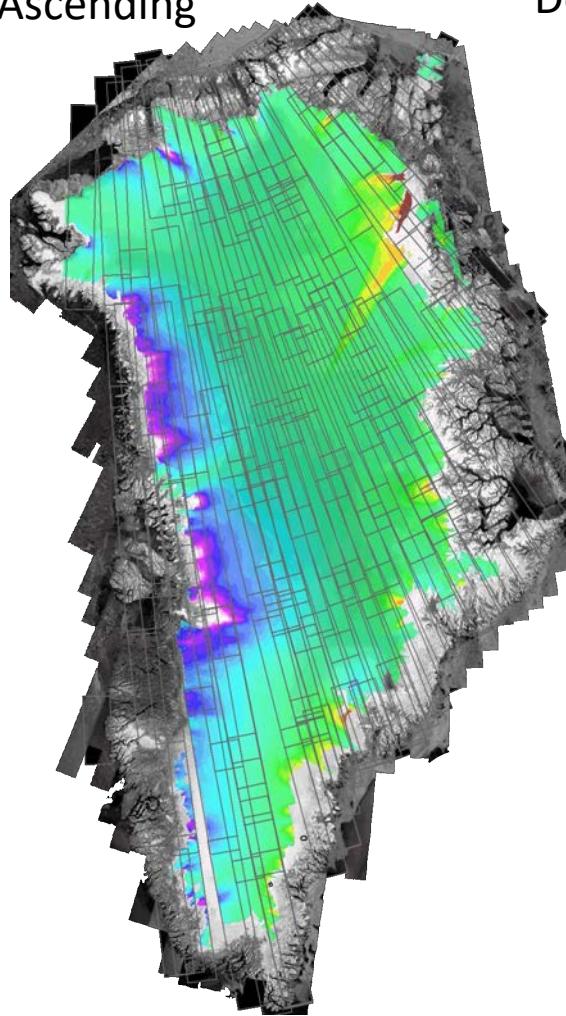


Quantifying Ground Deformation in the Los Angeles and Santa Ana Coastal Basins Due to Groundwater Withdrawal, B. Riel et al., *Water Resources Res.*, **54**, doi:10.1029/2017WR021978, 2018.

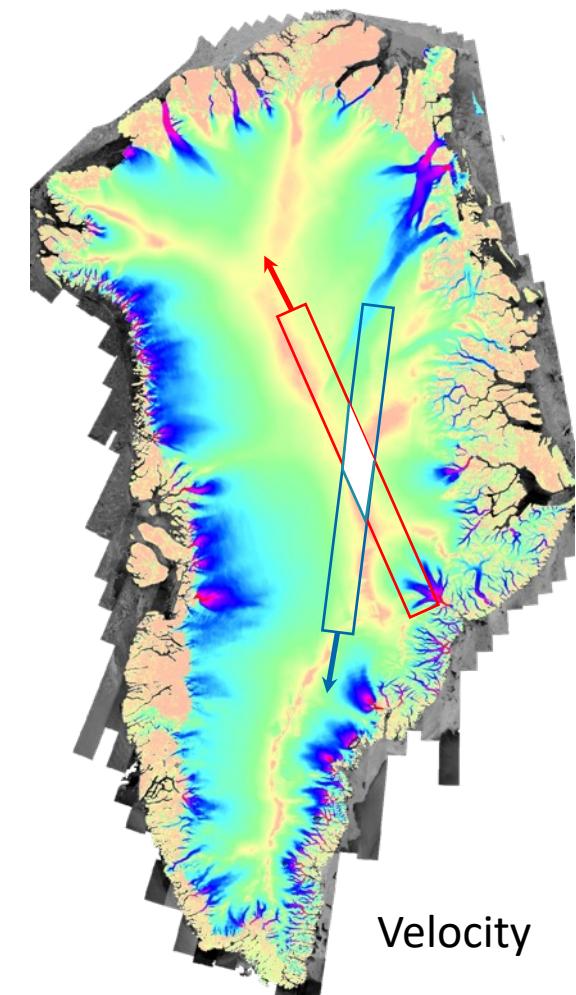
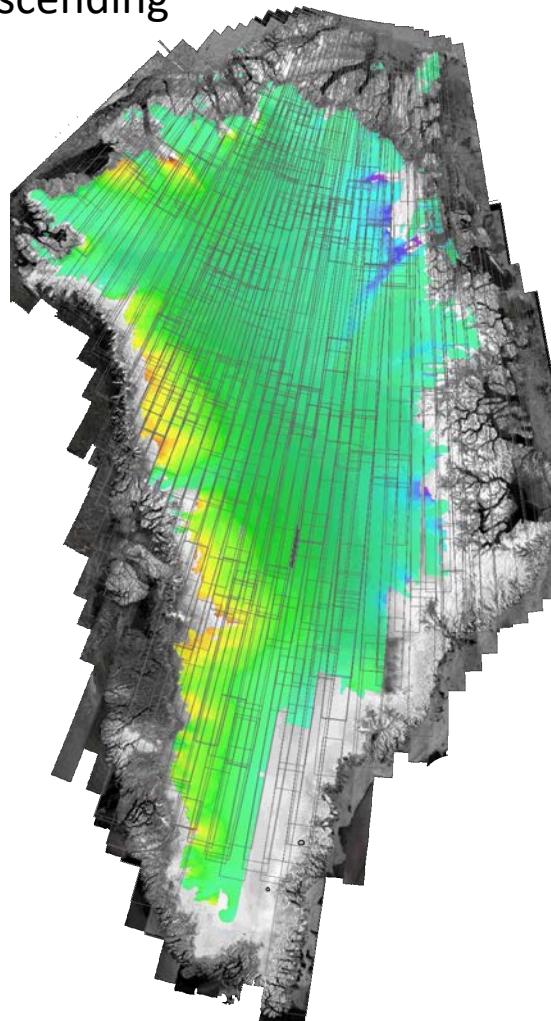
Courtesy: M. Simons, B. Riel (Caltech)

Ice Sheet Velocities and Variability

Ascending



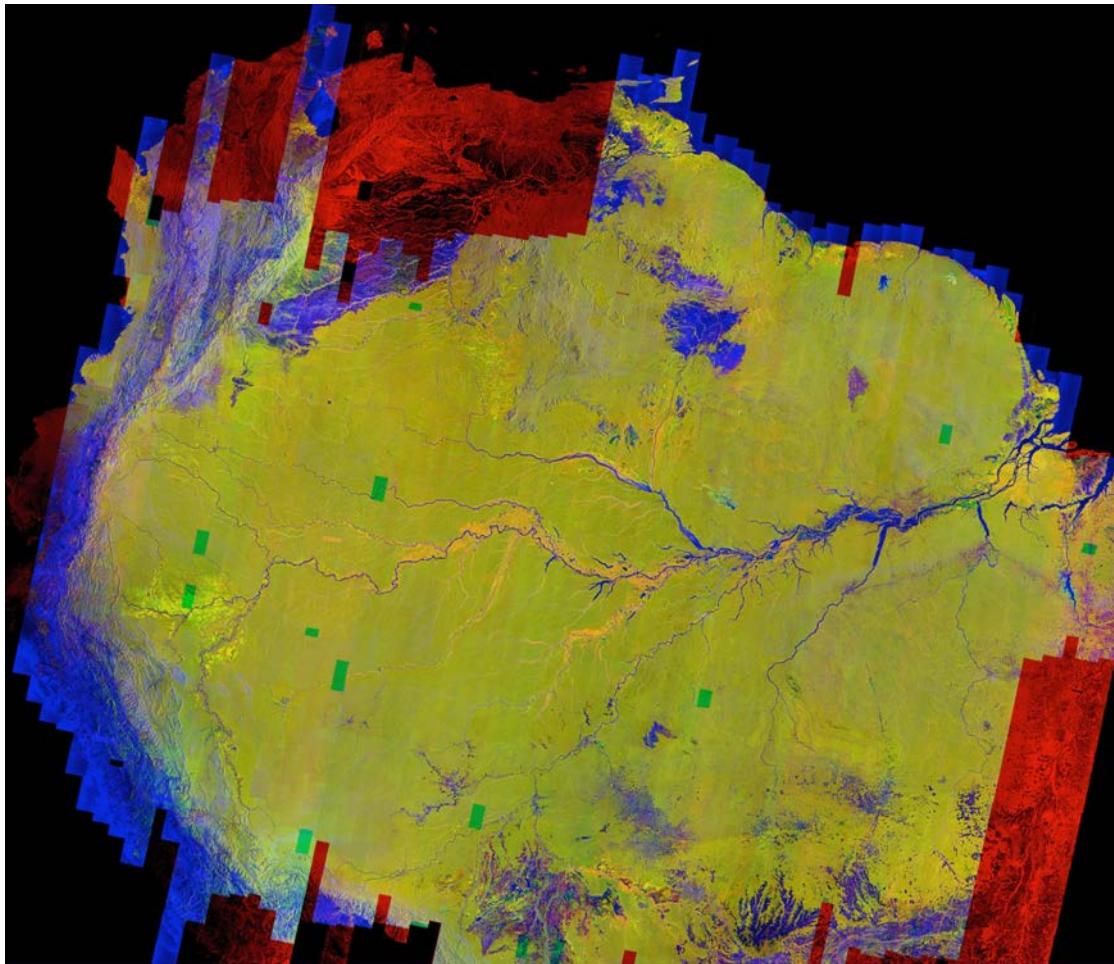
Descending



Velocity

Courtesy: I. Joughin (U. Wash/APL)

Carbon Cycle Monitoring – Time Series for Biomass and Disturbance



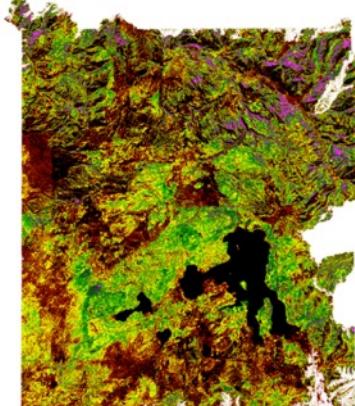
ALOS-1 Radar Image Mosaic of Amazon



Courtesy: P. Siqueira (U. Mass Amherst)



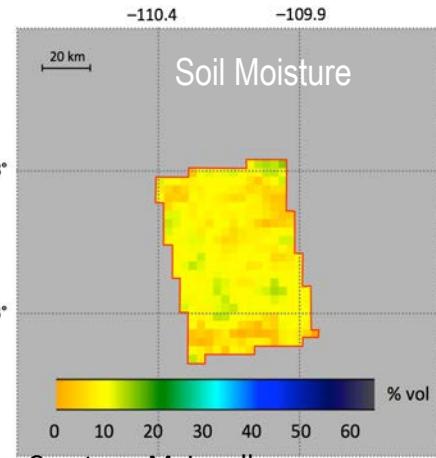
Forest Aboveground Biomass
Yellowstone National Park



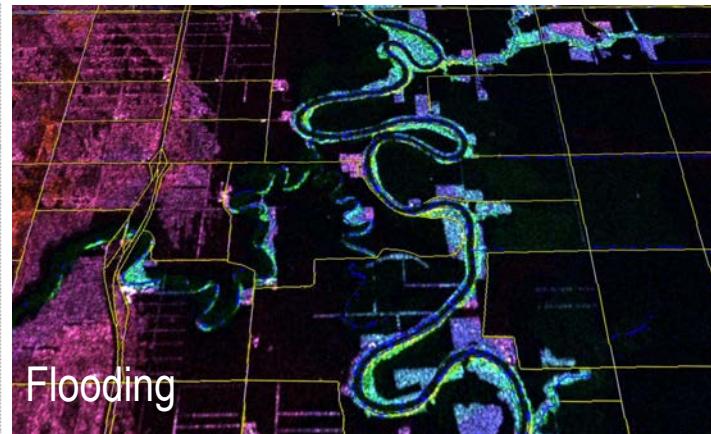
Biomass Mg/ha

- 0-25
- 25-50
- 50-75
- 75-100
- 100-150
- 150-200
- 200-250
- 250-300
- > 300

Courtesy: S. Saatchi



Courtesy: M. Lavalle

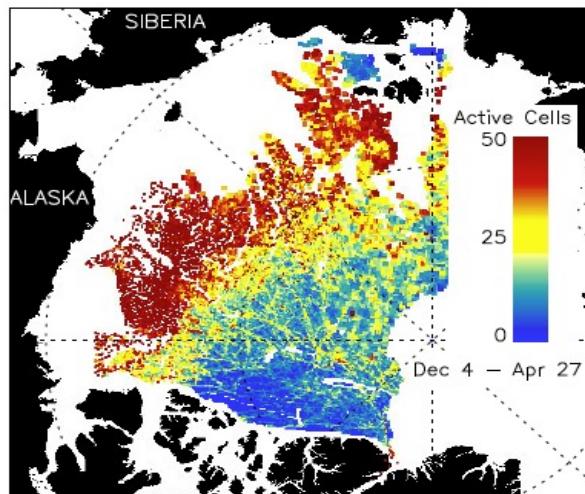


Flooding

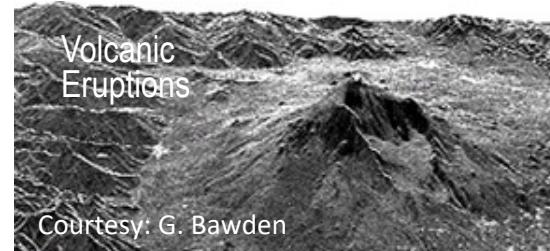
Courtesy: G. Breckenridge/S. Nghiem

Courtesy: S.-H. Yun

Courtesy: R. Kwok



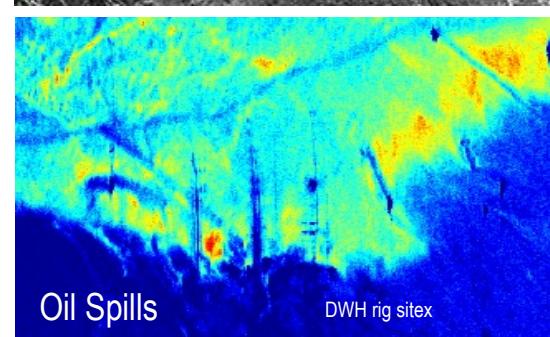
Sea Ice Extent/ Ice and Ship Tracking



Courtesy: G. Bawden

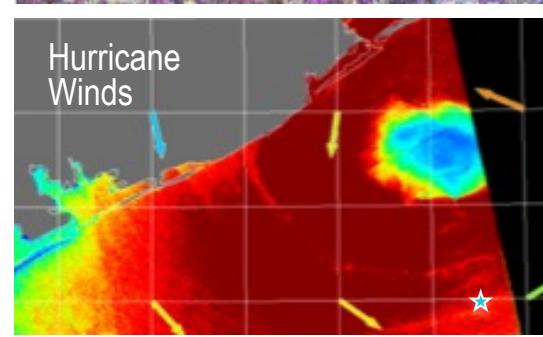


Tornado Damage



Oil Spills

Courtesy: C. Jones



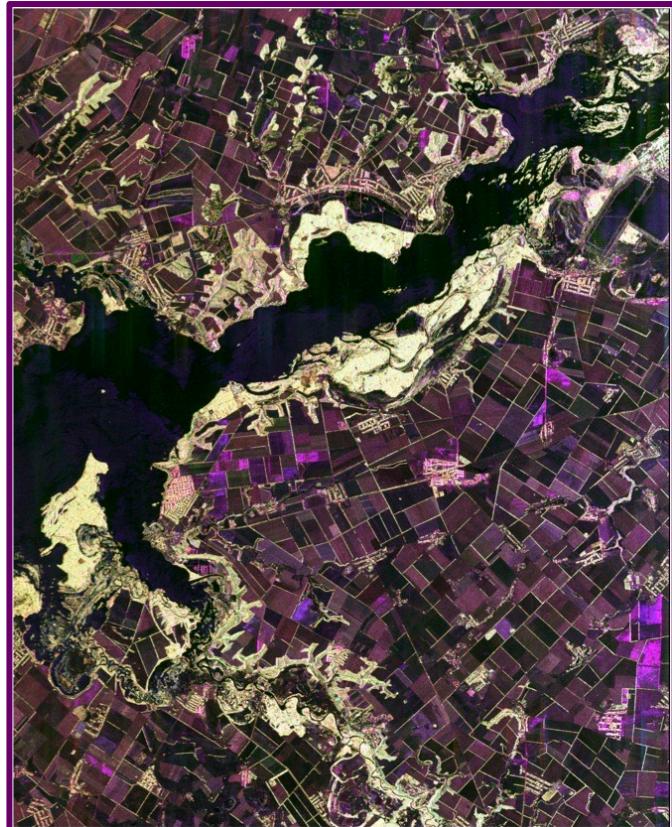
Hurricane Winds

Courtesy: G. Bawden

Benefits of both US-contributed L-band SAR and India-contributed S-band SAR



- Global L-band and *globally-distributed but targeted* S-band data with unprecedented spatial and temporal sampling will drive new directions in science and applications, including high-resolution soil-moisture and crop assessments



**Wheat Fields,
Dnieper
River, Ukraine**

Red: LHH
Green: LHV
Blue: CHV

**Rubber,
banana, and
oil palm trees,
Muar,
Malaysia**



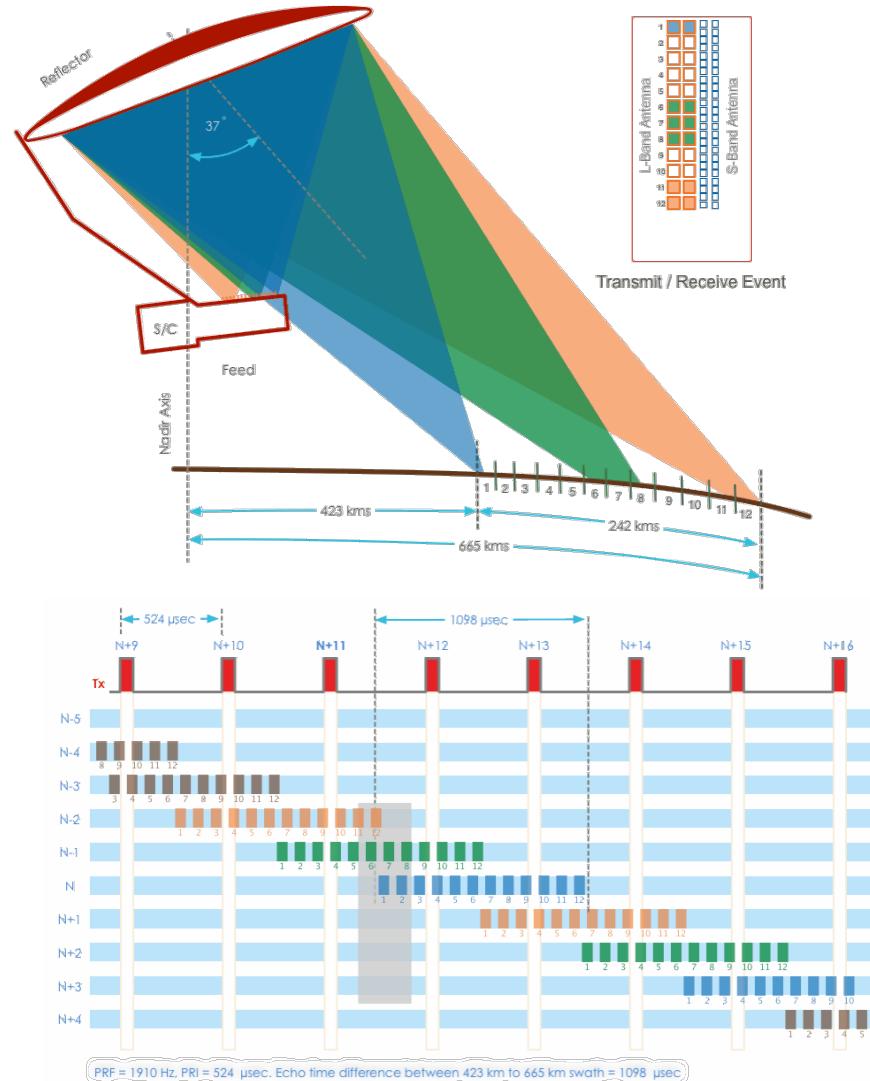
Examples of dual-frequency measurements from SIR-C/X-SAR

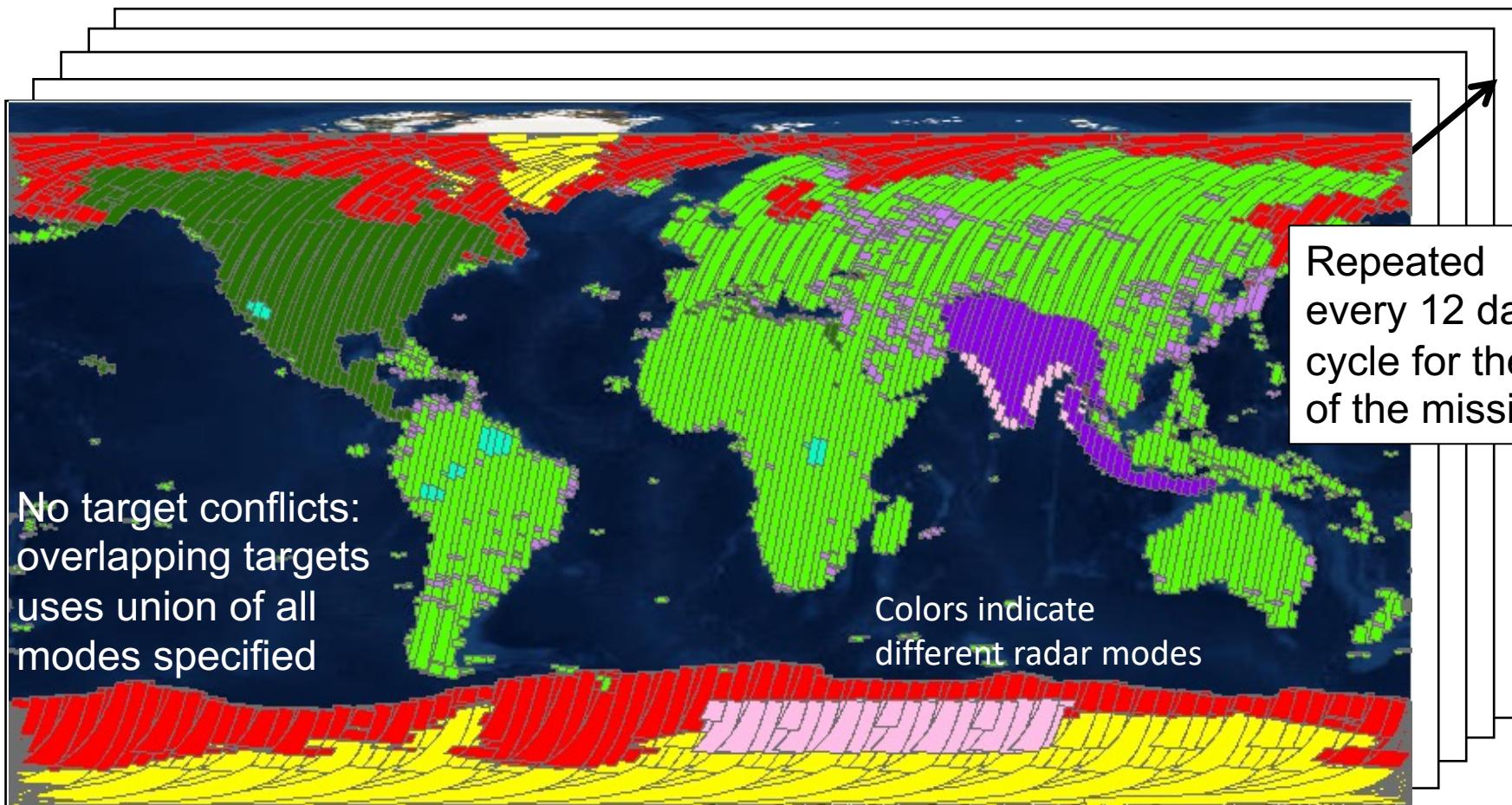
- **SweepSAR Basics**

- On Transmit, illuminate the entire swath of interest (red beam)
- 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





Persistent updated measurements of Earth 1.6 PB raw data per year
Level-2 global products

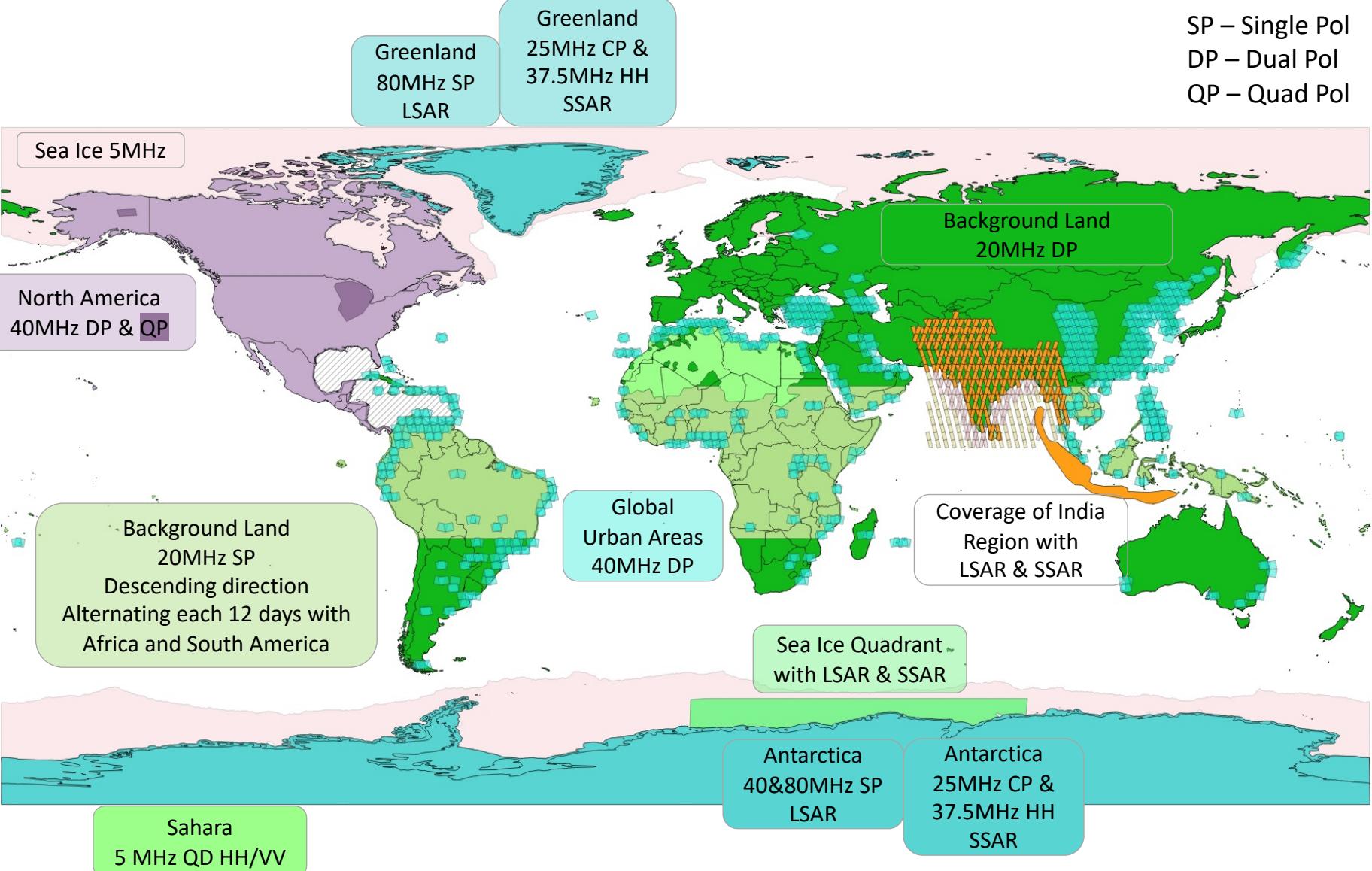
J. Doubleday
P. Sharma, JPL

- Observation strategy employs a small subset of possible modes

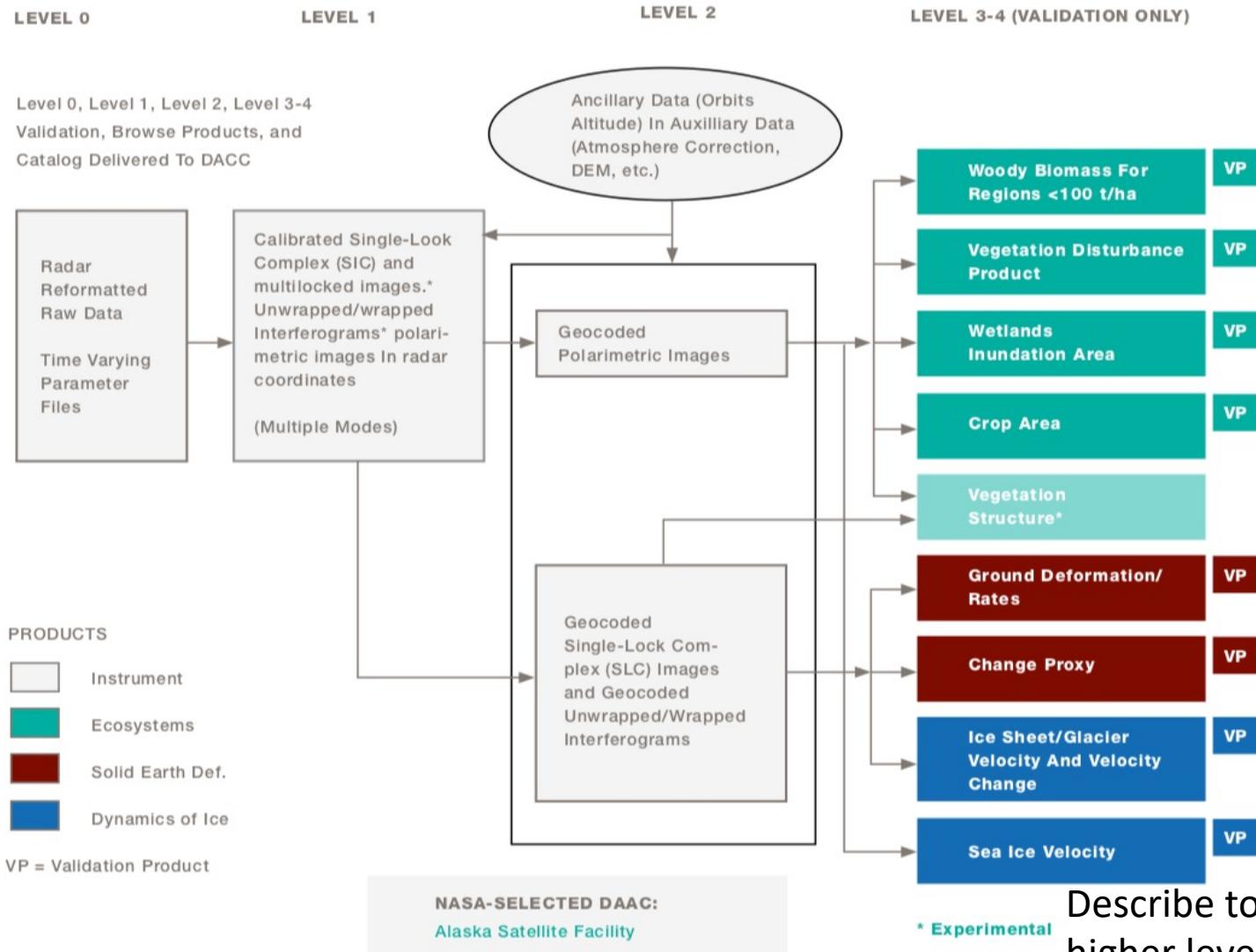
Observation Strategy	L-band		S-band		Culling Approach	
Science Target	Mode ⁺	Resolution	Mode	Resol.	Sampling	Desc Asc
Background Land	DP HH/HV				cull by lat	
Land Ice	SP HH				cull by lat	
Sea Ice Dynamics	SP VV				s = 1 p	
Urban Areas					s = 1 p	
US Hi-Res					s = 1 p	
Himalayas			CP RH/RV		s = 1 p	
India Agriculture					s = 1 p	
India Coastal Ocean			DP HH/HV or VV/VH		s = 1 p	
Sea Ice Types	DP VV/VH				s = 3 p	

Current Observation Plan Observation

Revised every 6 months



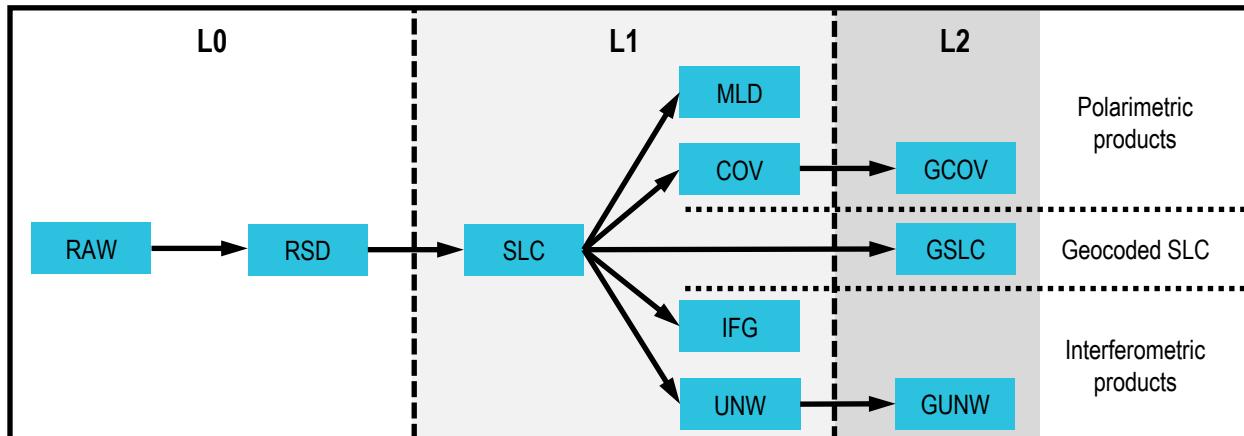
NISAR – Mission Data Products



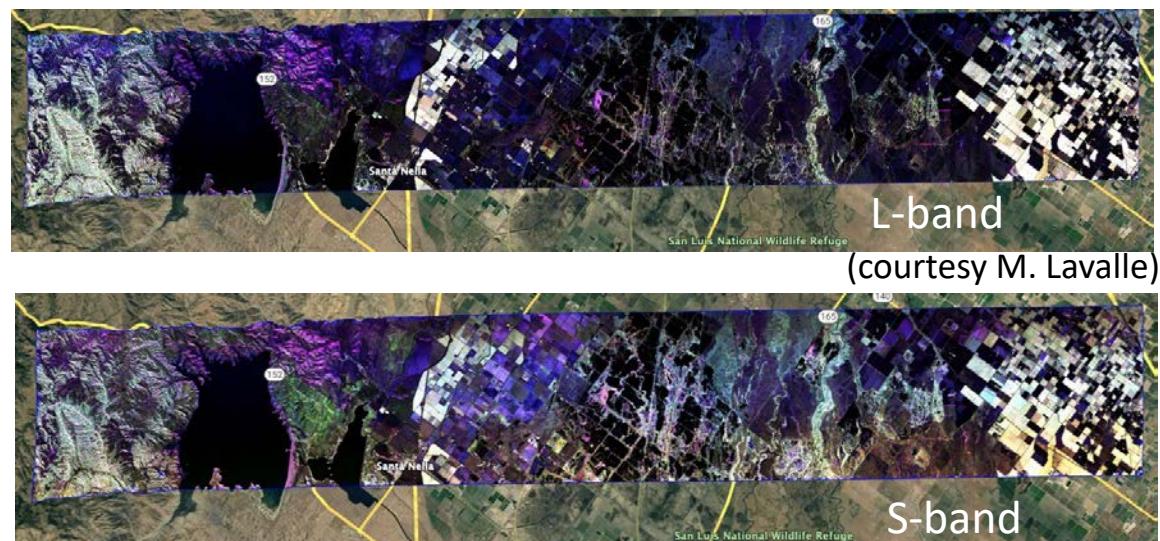
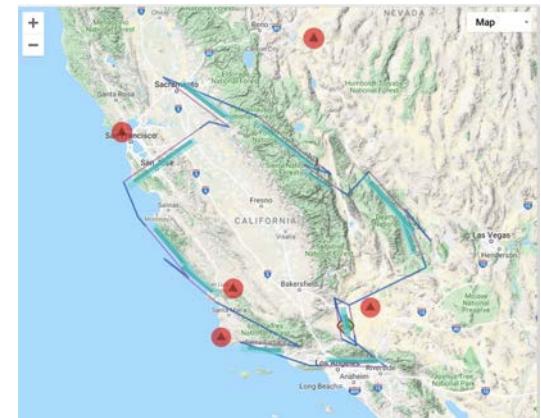
Describe tools for higher level products

Science Data System Summary

- Ingest 35 Tbits (4.4 TB) of raw data per day on average
- Automatically generate L-SAR L0a, L0b, L1, and L2 science products (> 70TB/day)
 - Generate S-SAR L0 science product for data downlinked through NASA Ka-band
- Perform bulk reprocessing twice during mission
 - 8 months of data after L2 product validation at 4x rate
 - 12 months of data at end of mission at 3x rate
 - Anticipate assessing additional processing / reprocessing options before launch
- Sample products derived from UAVSAR data, processed like NISAR, are available
 - <https://uavstar.jpl.nasa.gov/science/documents/nisar-sample-products.html>
- Open source (github) ISCE3 software already available, support these workflows and products



- 150+ L+S band polarimetric data sets from US ASAR Airborne campaigns over a range of NISAR science-related targets: Agriculture, Soil Moisture, Forests, Glaciers, Sea-ice, landslides
- 2019 Western Campaign
- 2021 East Coast Campaign
- Data Sets available at ASF DAAC



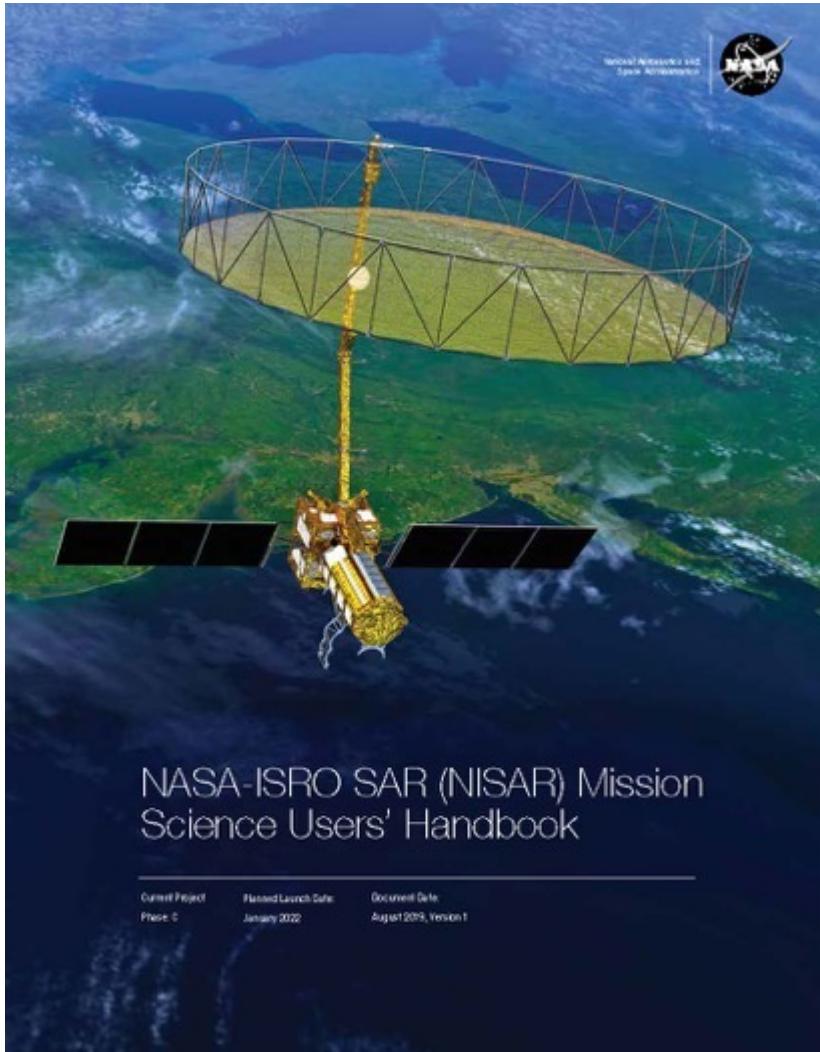
ASAR geocoded products generated through NISAR L2 processor

Science Data System Products Latency

Products	Requirement	Current Best Estimate	Urgent Response
L0	24 Hours	12 Hours	2 Hours
L1	9 Days	1 Day	4 Hours
L2	9 Days	2 Days	6 Hours

Note: SDS is sized to produce this data within 1 day latency, so the real bottleneck is receiving all the ancillary files, specifically the Medium accuracy Orbit Ephemeris from GPS.

Summary



- NISAR Instrument and Engineering Payload Integration and Test rapidly proceeding
- Integration with spacecraft planned to begin early 2023
- Global products to Level 2 fully and openly available to the global community
- Cloud-based data, tools and services to facilitate access and use
- Anticipated launch of NISAR in 2023/2024

For more information: <https://nisar.jpl.nasa.gov>



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