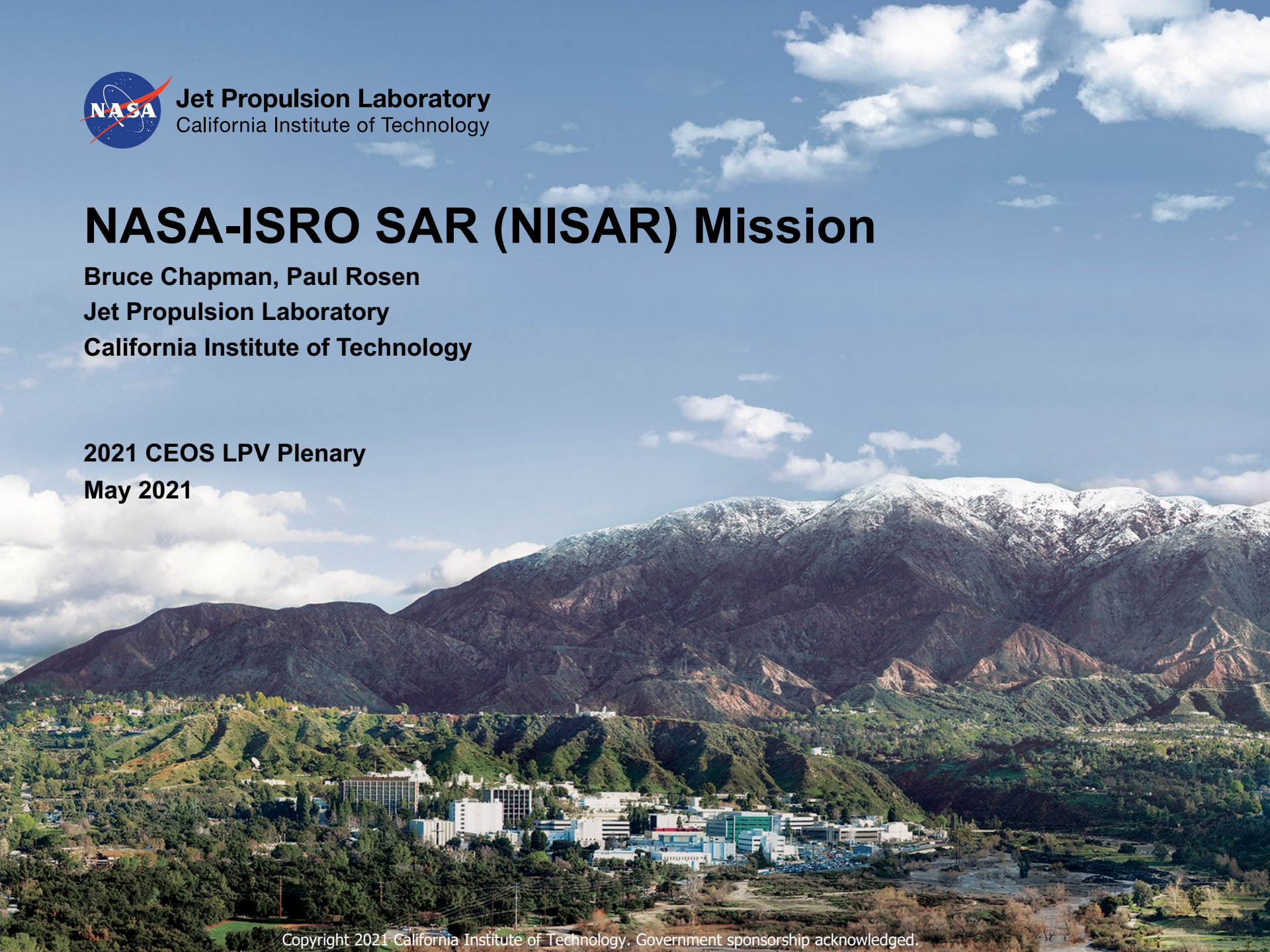


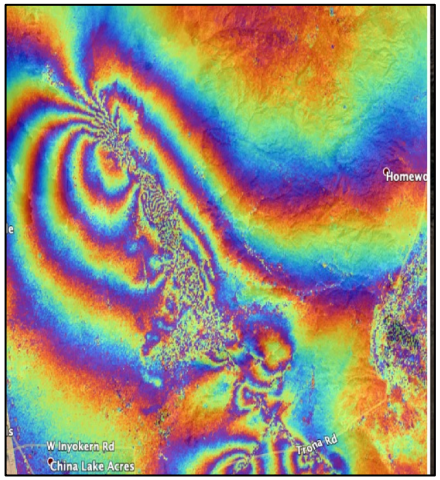
Jet Propulsion Laboratory
California Institute of Technology

NASA-ISRO SAR (NISAR) Mission

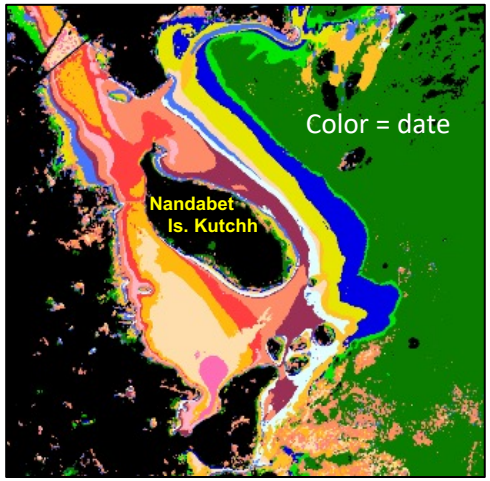
Bruce Chapman, Paul Rosen
Jet Propulsion Laboratory
California Institute of Technology

2021 CEOS LPV Plenary
May 2021

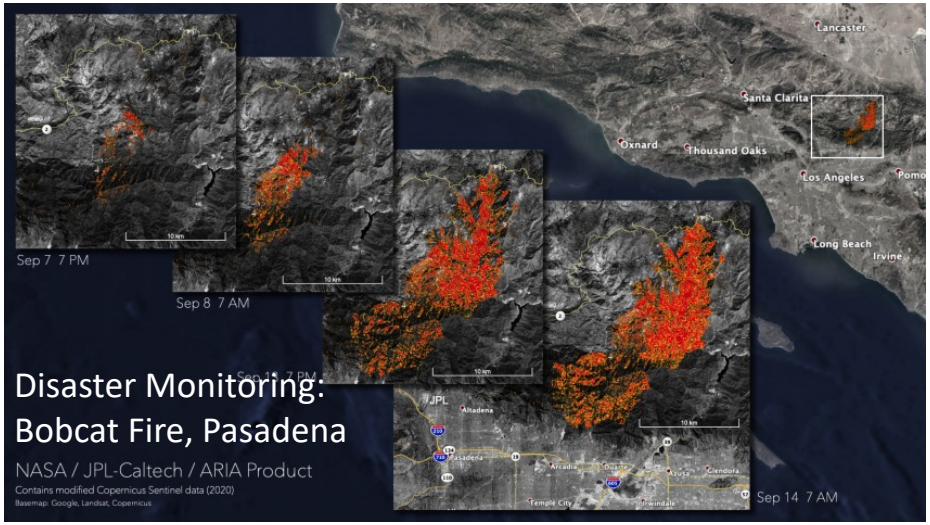
NISAR Science Capturing a Dynamic Earth



Earthquake Dynamics, Ridgecrest



Wetland Inundation, India



Disaster Monitoring: Bobcat Fire, Pasadena

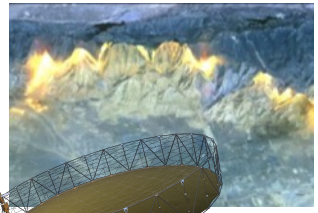
- **Dynamics of Ice: Ice sheets, Glaciers, and Sea Level**
  - *Will there be catastrophic collapse of the major ice sheets, including Greenland and West Antarctic and, if so, how rapidly will this occur?*
  - *What will be the resulting time patterns of sea-level rise?*
  - *How are alpine glaciers 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 Science Observation Overview

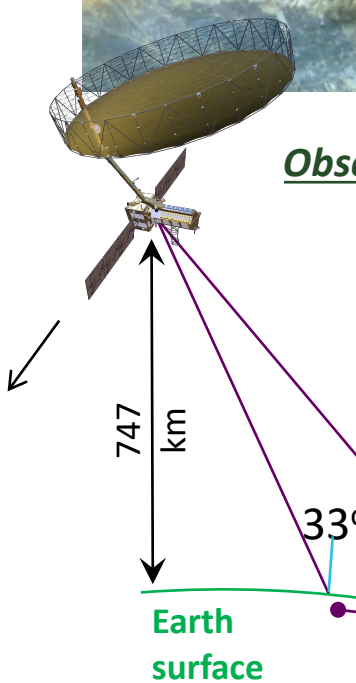
NISAR Characteristic:	Would Enable:
L-band (24 cm wavelength)	Low temporal decorrelation and foliage penetration
S-band (9.4 cm wavelength)	Sensitivity to light vegetation
SweepSAR technique with Imaging Swath > 240 km	Global data collection
Polarimetry (Single/Dual/Quad)	Surface characterization and 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

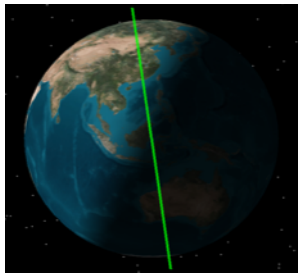
NISAR Will Uniquely Capture the Earth in Motion






Observation Geometry



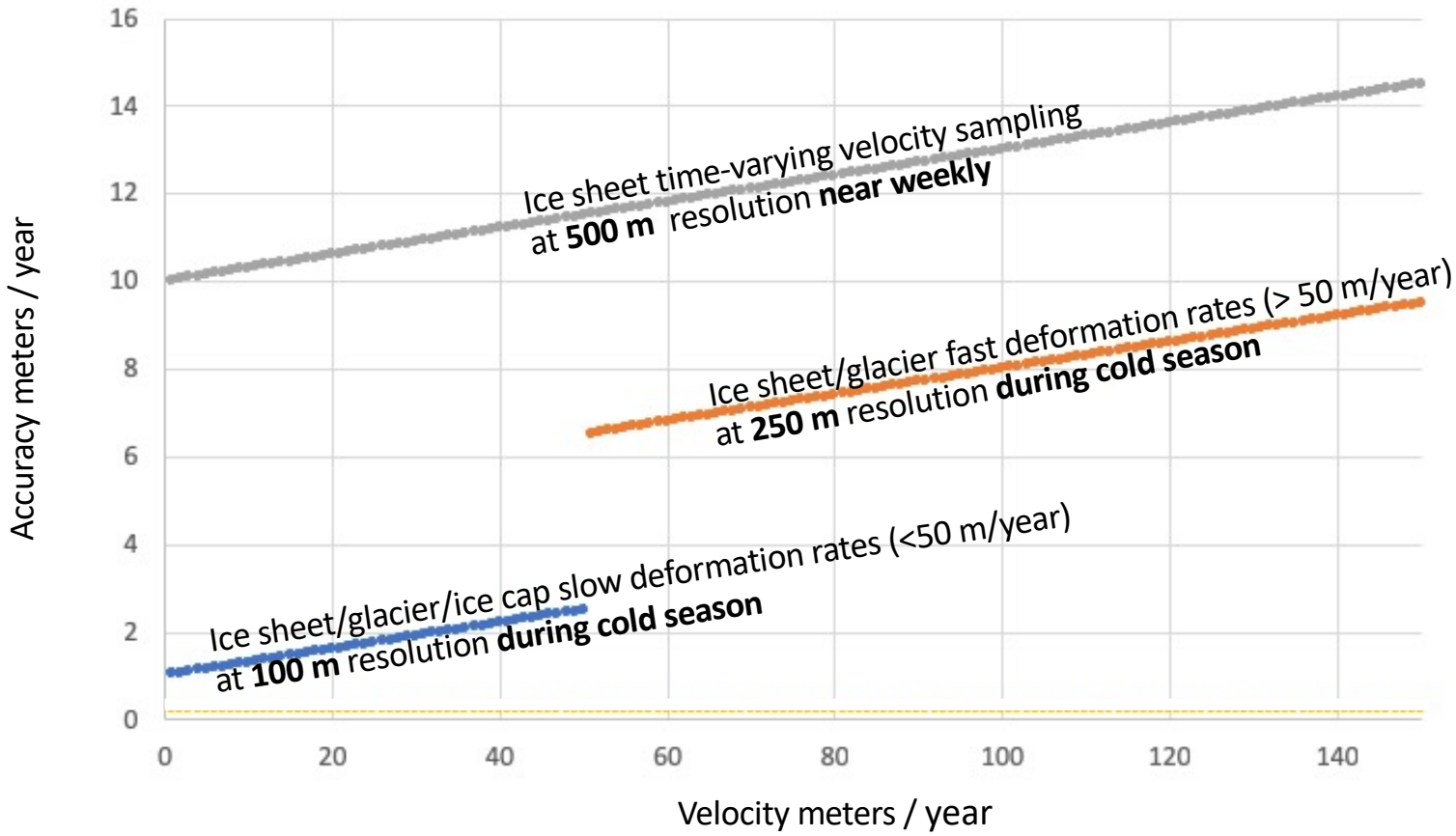


6 AM / 6 PM

13 level-2 science measurement requirements

- NISAR will produce Level 3 science measurement products over Cal/Val sites to validate those measurement requirements
  - Algorithms for producing the level-3 products may have parameters that must be calibrated as well.
- NISAR is also supporting the production of a validated global soil moisture product, that will be produced for every collected image over land.
- NISAR must also demonstrate the capability to change the observation plan and achieve reduced processing latency for urgent response.

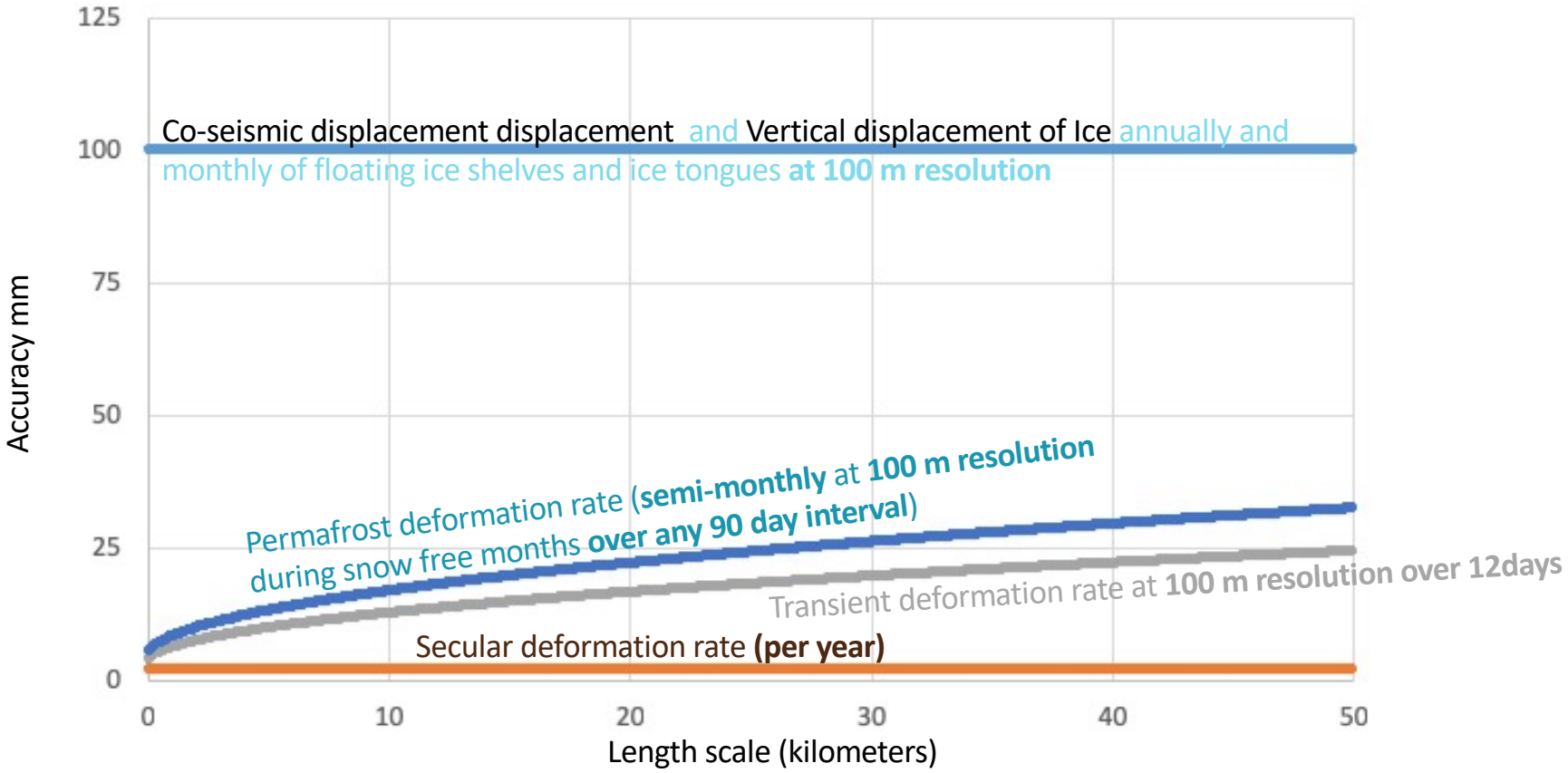
Required accuracy of horizontal velocity measurements by NISAR



And: sea ice velocity at 100 m/day accuracy on a 5 km grid every 3-days

Validated with deployed GPS on ice

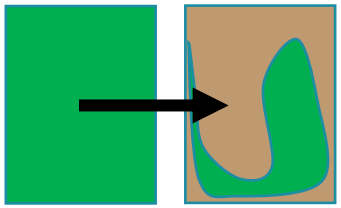
Required accuracy of relative displacement measured by NISAR



Validated with GNSS networks or deployed GPS

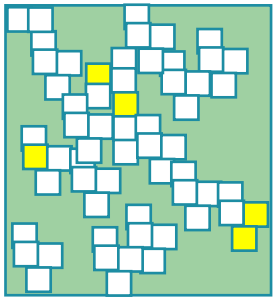
Ecosystem Measurement Requirements

Detection of Forest disturbance



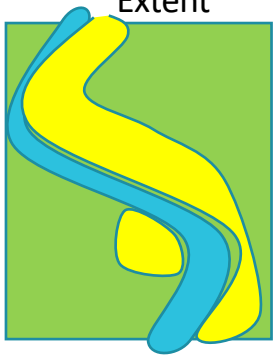
Accuracy: 80% for disturbances > 50% at ha scale **annually**

Active agricultural crop area



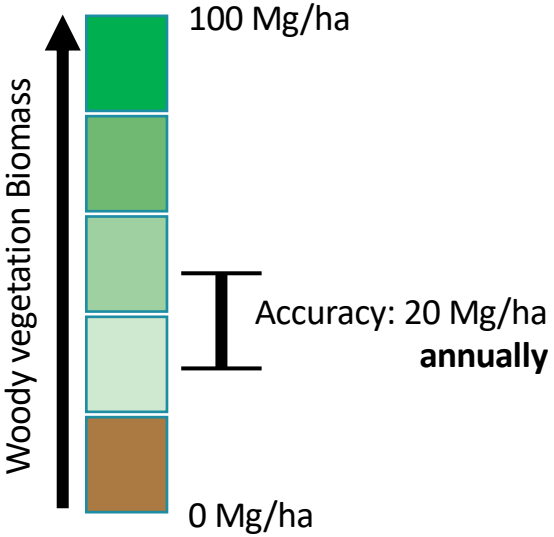
Accuracy: 80% at 1 ha resolution **every 3 months**

Wetland inundation Extent



Accuracy: 80% at 1 ha resolution **every 12 days**

Biomass

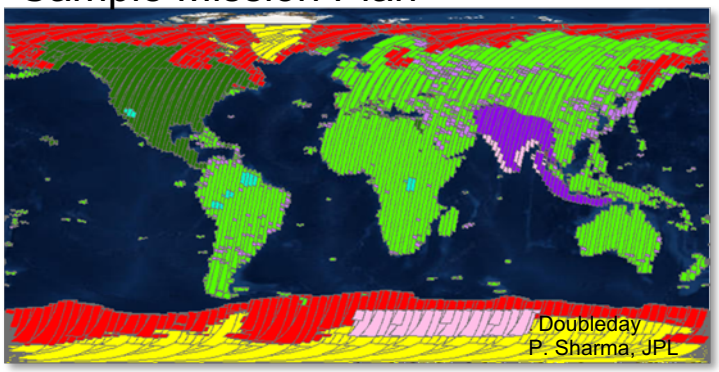


Over 1 hectare

Validated with field measurements and/or other remote sensing data

NISAR Science Performance and V&V Healthy Margins

Sample Mission Plan



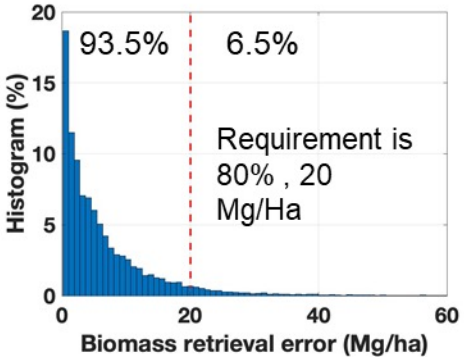
Persistent updated measurements of Earth

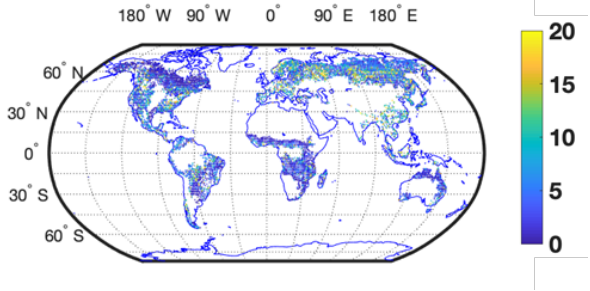
- Science Performance Tool now using as-built instrument measurements
- Performance metrics have been stable throughout Phase C
  - **Solid Earth** and **Biomass** metrics shown at right
  - Also metrics for Glacier velocity and disturbance

Solid Earth Performance	Coverage Req.	Coverage Est.	Uncertainty Req.	Uncertainty Est.	Status
Level 1 in mm	70%	82.5%	3.5 * (1+sqrt(L))	3.01 * (1+sqrt(L))	OK - OK
Coseismic (660) in mm	70%	81.0%	4 * (1+sqrt(L))	3.11 * (1+sqrt(L))	OK - OK
Transients (663) in mm	70%	86.6%	3 * (1+sqrt(L))	2.32 * (1+sqrt(L))	OK - OK
Active (658) in mm/yr	70%	93.7%	2	1.47	OK - OK
PermaFrost in mm	80%	84.9%	4 * (1+sqrt(L))	2.40 * (1+sqrt(L))	MARGIN-OK

Level 2

0.1 km < L < 50 km) Meets requirements with > 10% margin / < 10% margin

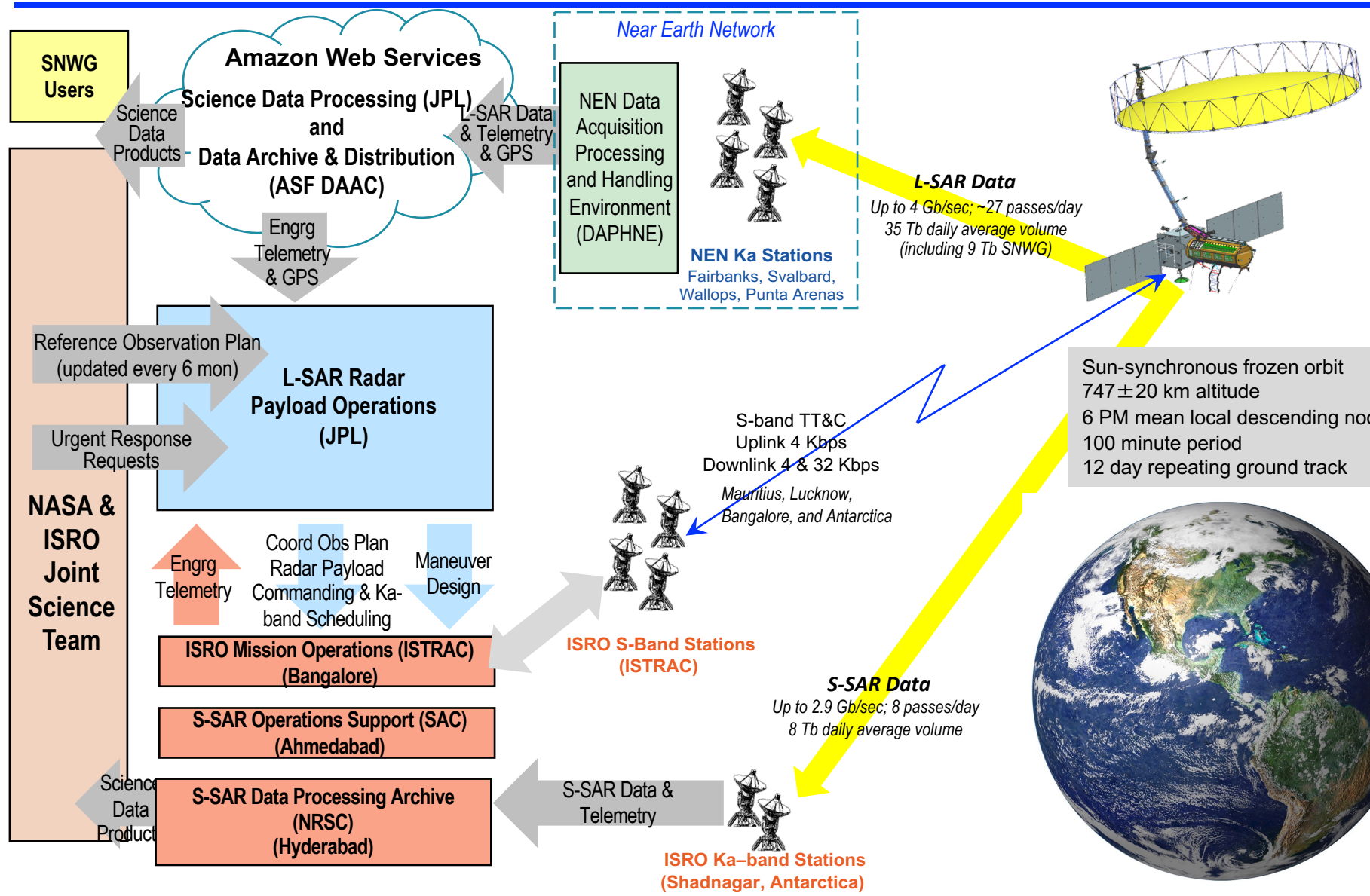




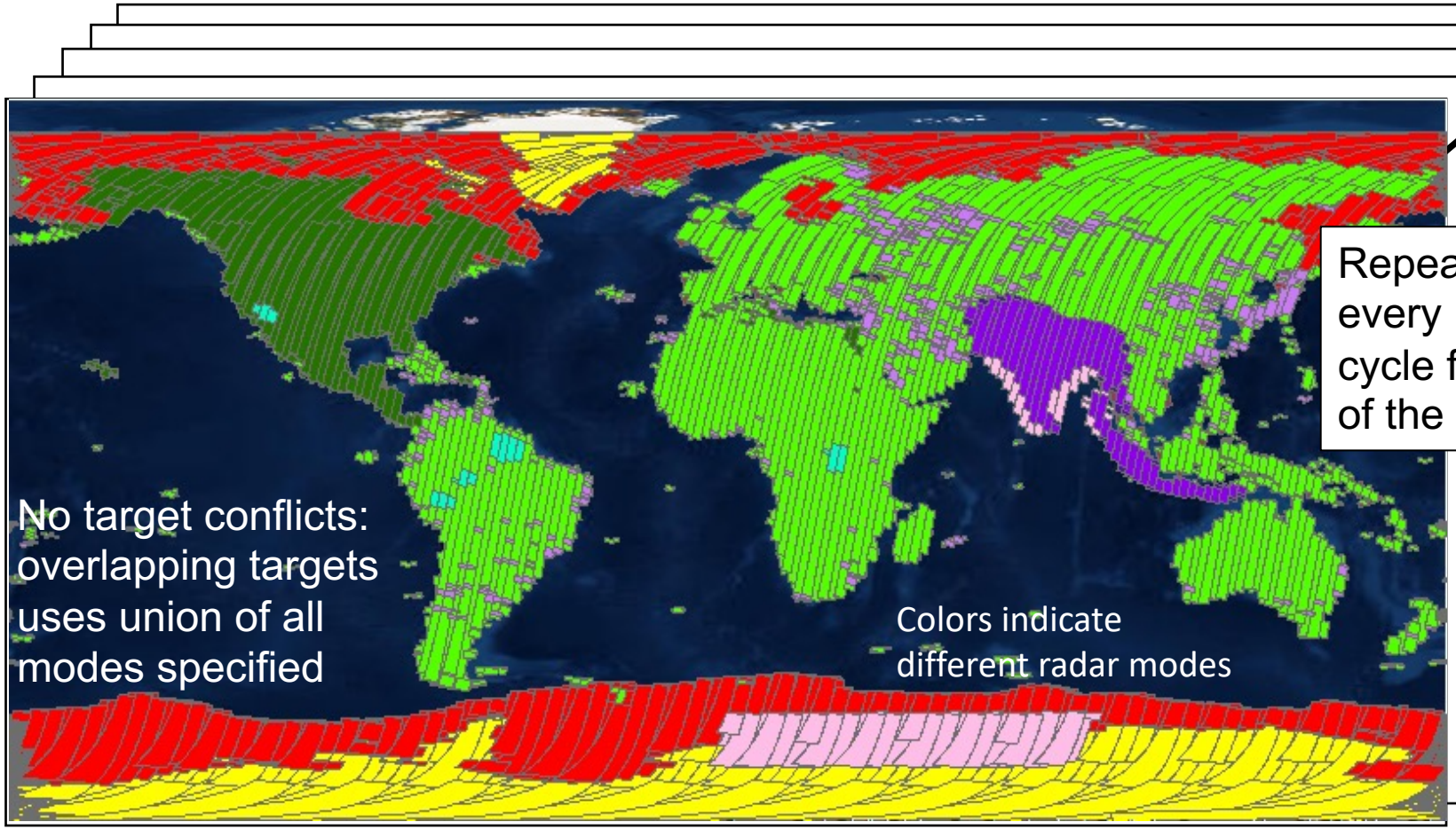
Sample Biomass Metrics

- Science will participate in V&V by interactive process with Radar and Mission Systems engineering to update instrument performance with mission plan in performance tool estimates.

NISAR Operations Overview



NISAR Systematic Observations

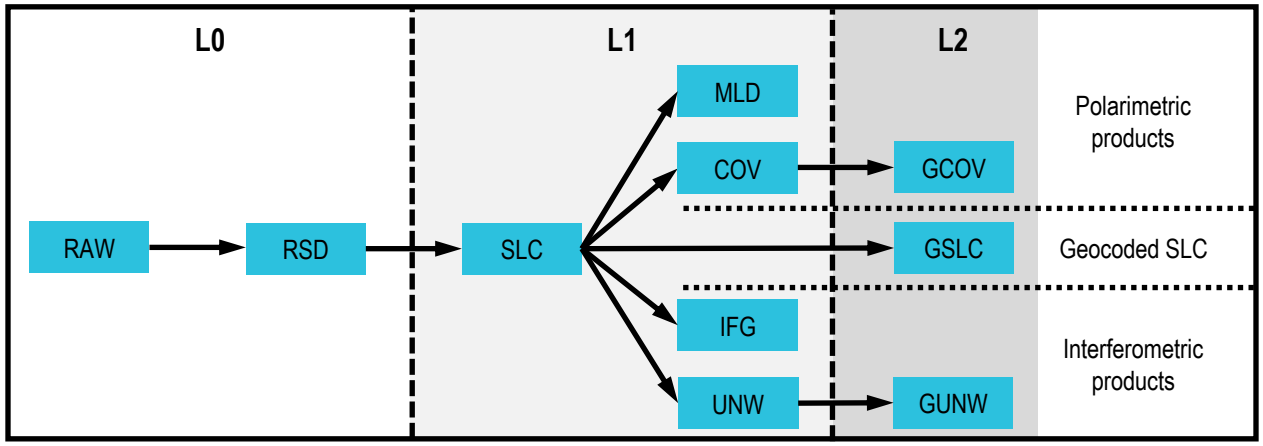


J. Doubleday
P. Sharma, JPL

Persistent updated measurements of Earth resulting in 1.6 PB raw data per year

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
  - Anticipate assessing additional processing / reprocessing options before launch
- SDS makes data available to NASA/ISRO project users and DAAC
- Sample products derived from UAVSAR data, processed like NISAR, are available
  - https://uavsar.jpl.nasa.gov/science/documents/nisar-sample-products.html
- Open source (github) ISCE3 software already available and is beginning to support these workflows and products

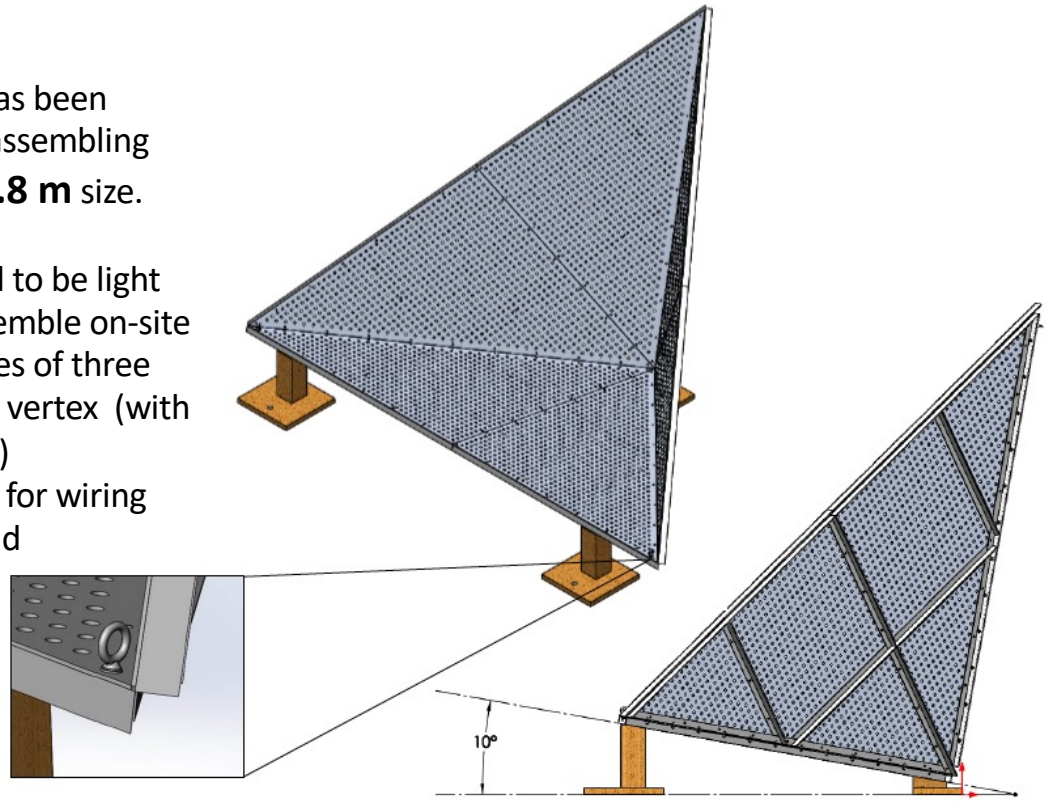


L-band image Calibration

Trihedral Corner Reflectors

A new design for L-Band Trihedral Reflectors has been implemented to optimize manufacturing and assembling requirements and to accommodate the new **2.8 m** size.

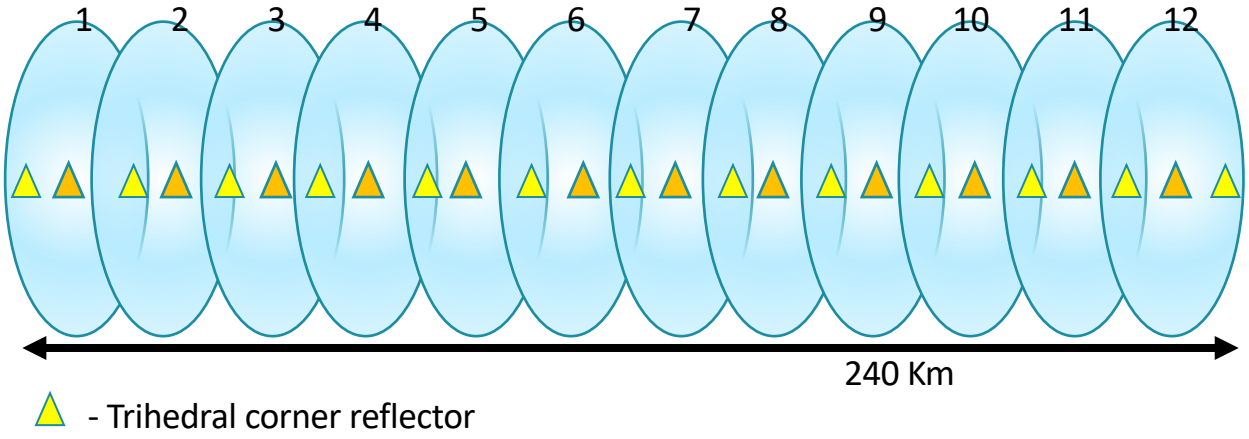
- The L-Band reflectors are to be manufactured to be light enough to carry by 1-2 people and easy to assemble on-site
- The reflector is propped up flat on the surfaces of three wooden bases, two in the front and one at the vertex (with variable tilts just be using different front bases)
- At the end of each corner is an eyebolt screw for wiring and attaching down to the stakes on the ground



Leonard Ortiz, JPL

L-band image Calibration

- NISAR will have 12 sub-beams
- An onboard digital beamforming algorithm will be used to form the NISAR 240 km range swath

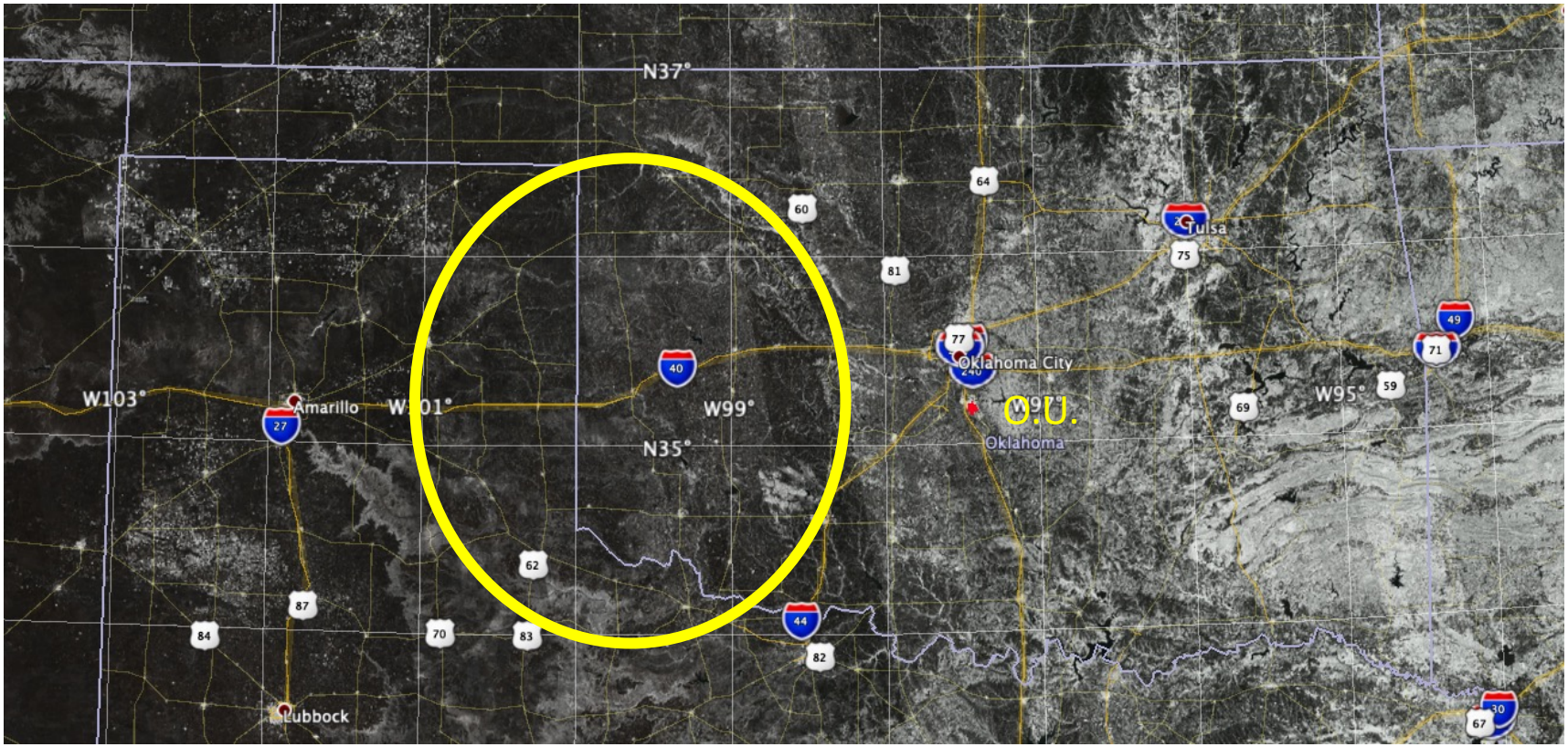


13 reflectors will be deployed at the edge of each sub-beam in beam overlap areas

12 reflectors will be deployed at the middle of each sub-beam

Bright distributed targets will be also used to evaluate the calibration across the sub-beam overlap areas

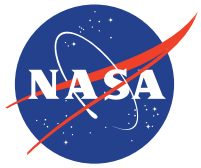
ALOS-1 L-HH image mosaic of Oklahoma



Reflectors to be deployed in Oklahoma and Alaska
Also will utilize the existing reflector array in California

Launch Date – Oct 2022 to Jan 2023

- NASA/JPL & ISRO have agreed to a new schedule plan that realistically results in a launch not later than late January 2023
  - Engineering delays and COVID-19 impacts have both contributed to delays
- L-SAR is fully integrated and in test;
- S-SAR is fully integrated and delivered to JPL for integration with L-SAR
- S-SAR is on a parallel I&T path with L-SAR – delivered to JPL in March 2021 and now being jointly integrated



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