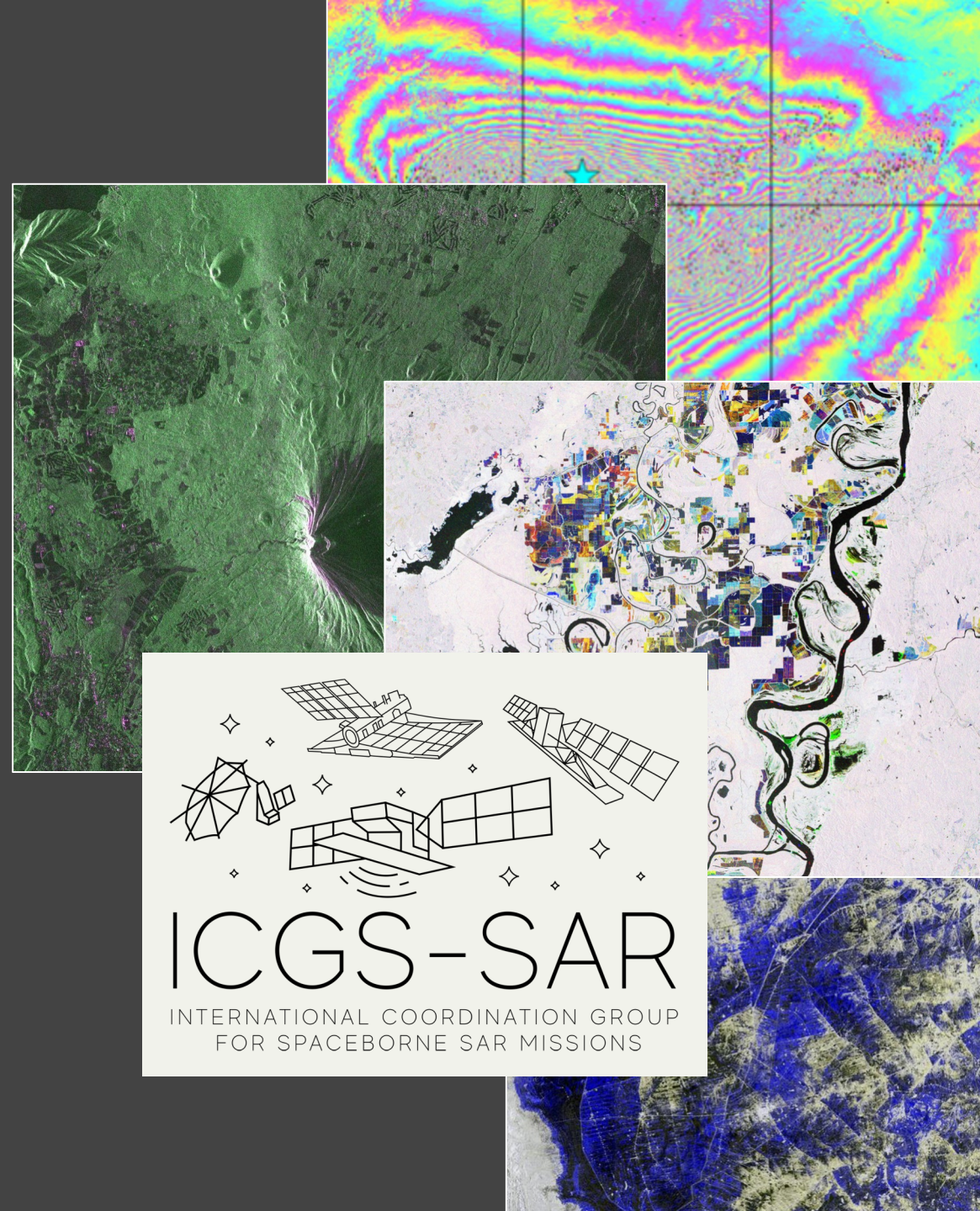
Third International SAR Workshop



Gerald Bawden, NASA
Agenda item 4.4

3rd International SAR Workshop
Saga Prefecture, Japan
6-8 November, 2024

National Aeronautics and
Space Administration

NASA earth

NASA's Geodetic Imaging Program

NISAR, SDC, UAVSAR➔AirSAR-NextGen, OPERA

Gerald Bawden, Ph.D.

Program Scientist

Earth Science Division

ICGS-SAR
INTERNATIONAL COORDINATION GROUP FOR SPACEBORNE SAR MISSIONS

Japan – November 2024



NISAR

- Status
- Observation Plan
- Products
- Urgent Response
- Commissioning



NISAR
NASA - ISRO SAR Mission

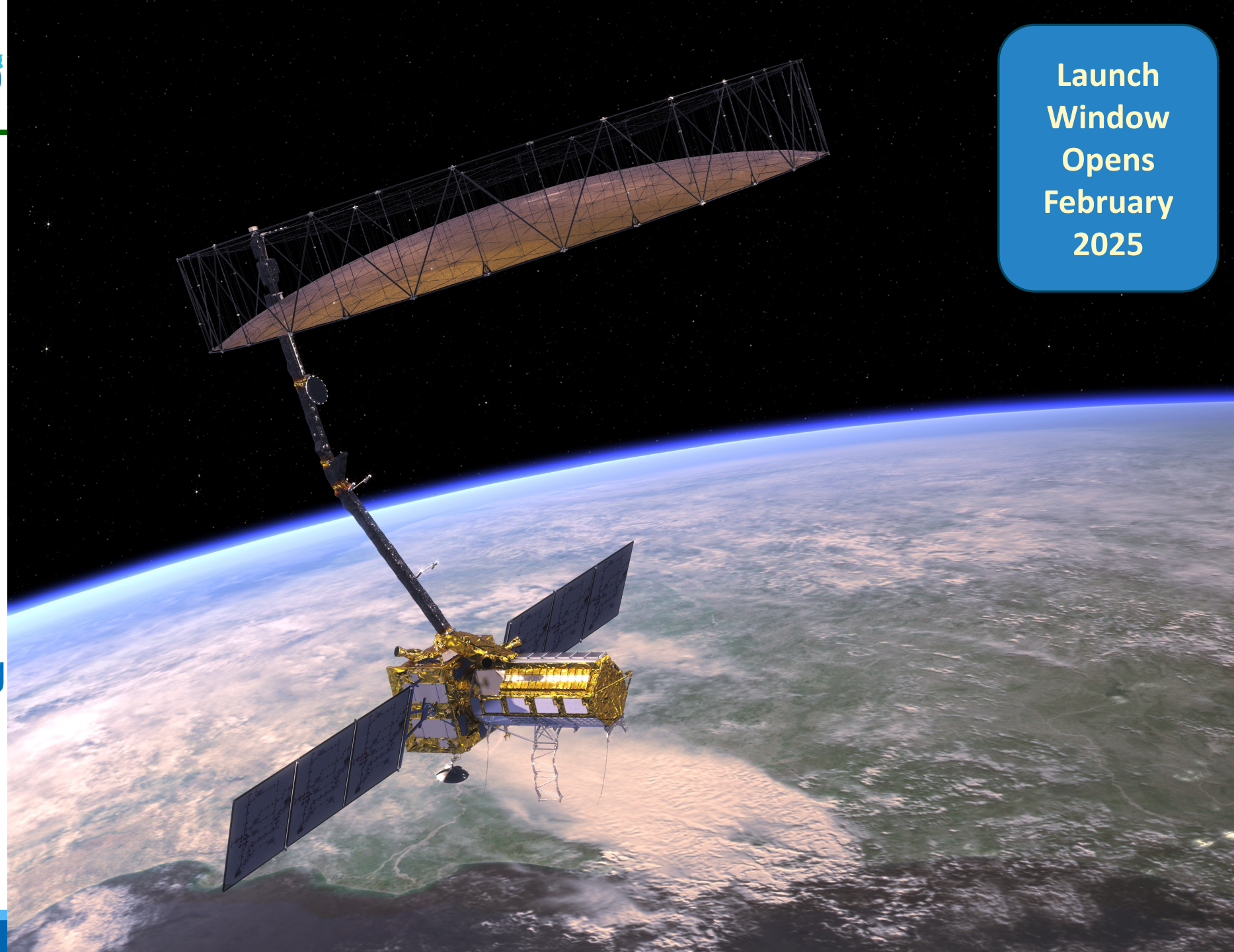
Partnership between NASA and ISRO

Dual frequency SAR
- L-band – 24 cm
- S-band –10 cm

12-day exact repeat for interferometry

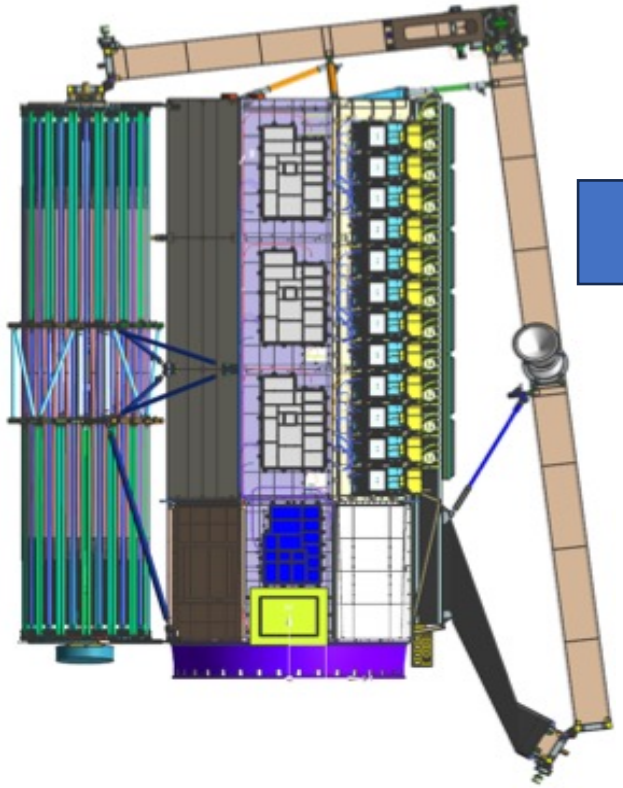
On average 6-day coverage with ascending and descending orbits

Near global land and ice coverage on every orbit

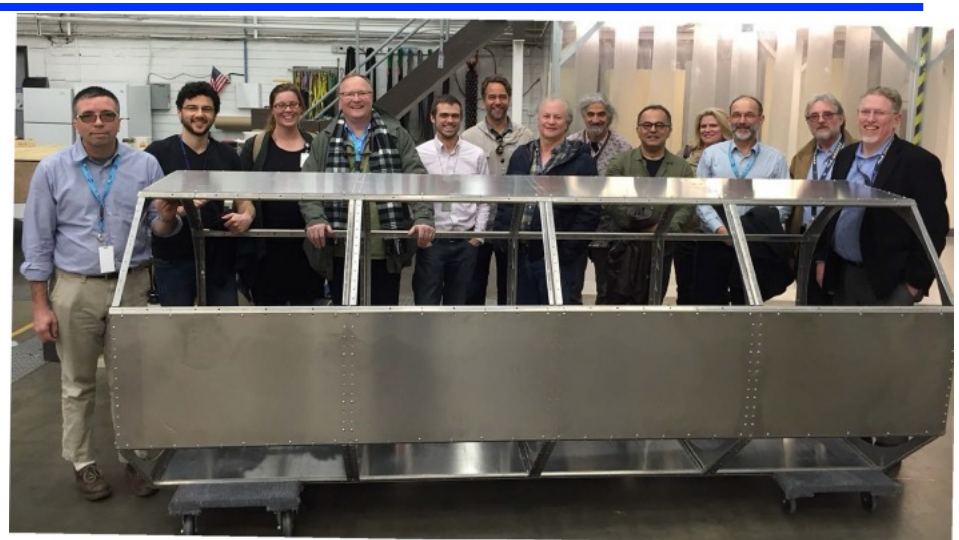


Launch Window Opens February 2025

NASA – ISRO Partnership – Concept to Reality





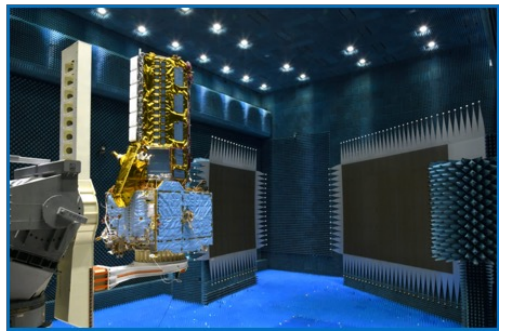


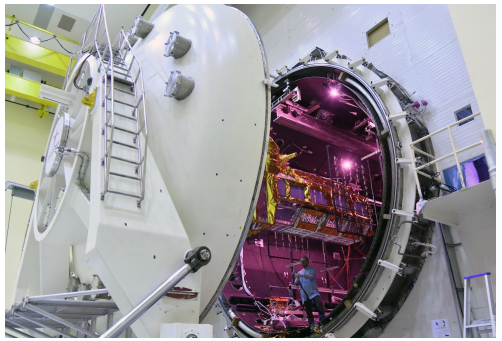


NISAR is 99.99% Completed and Tested



Launch Window Opens February 2025



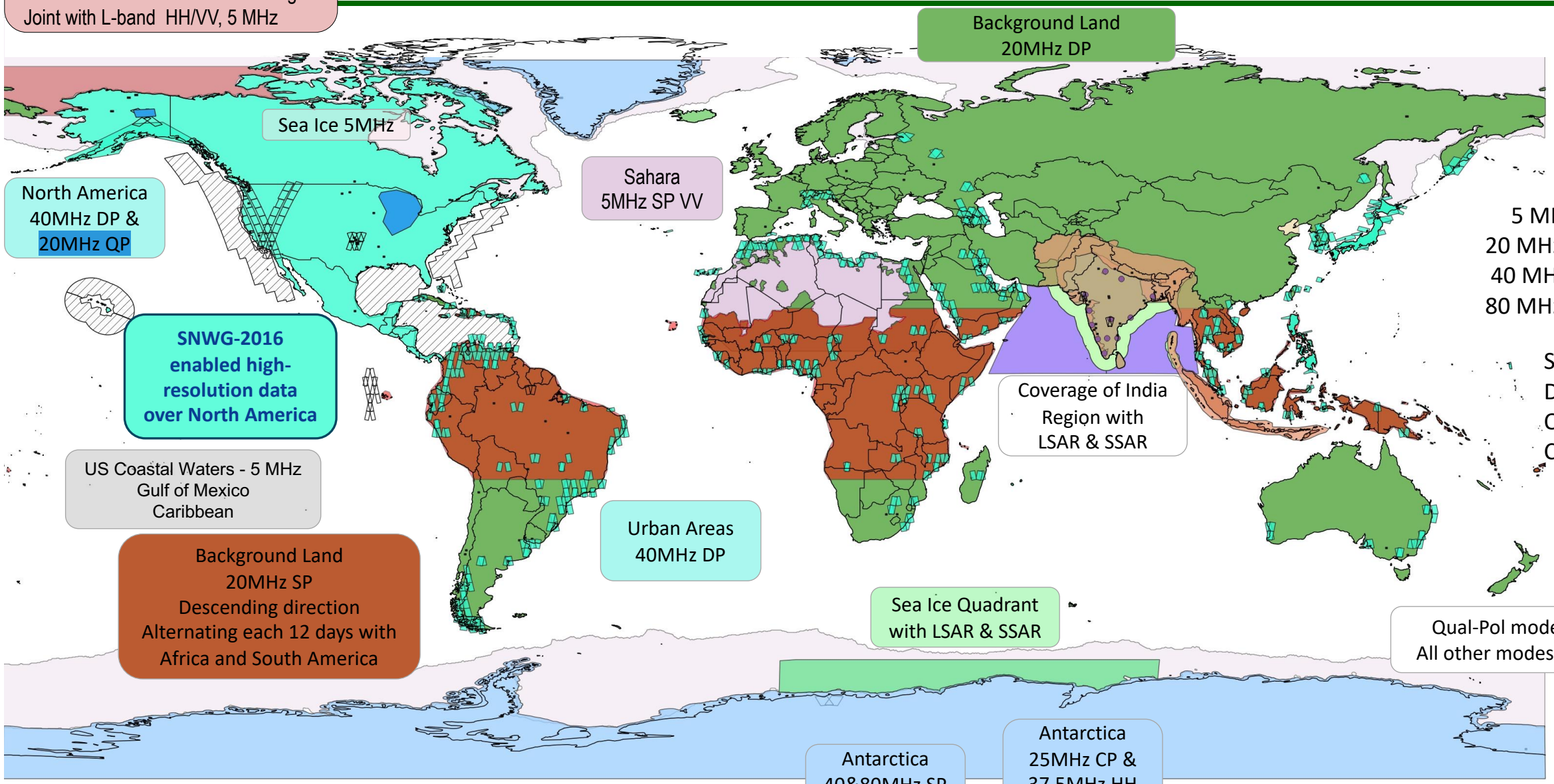




- January 2024: NISAR was completely integrated in India when testing and analysis identified a potential for the reflector to experience higher-than-previously-anticipated temperatures in its stowed configuration
- The reflector was removed and returned to California
- A special coating was added that will limit the temperature by reflecting more solar radiation off the reflector hardware
- The reflector returned to Bengaluru, India in October and is once again reintegrated with the radar observatory
- The launch readiness date will be determined by ISRO in coordination with NASA
- The earliest launch date: February 2025

NISAR L-SAR Observation Plan

Revised every 6 months



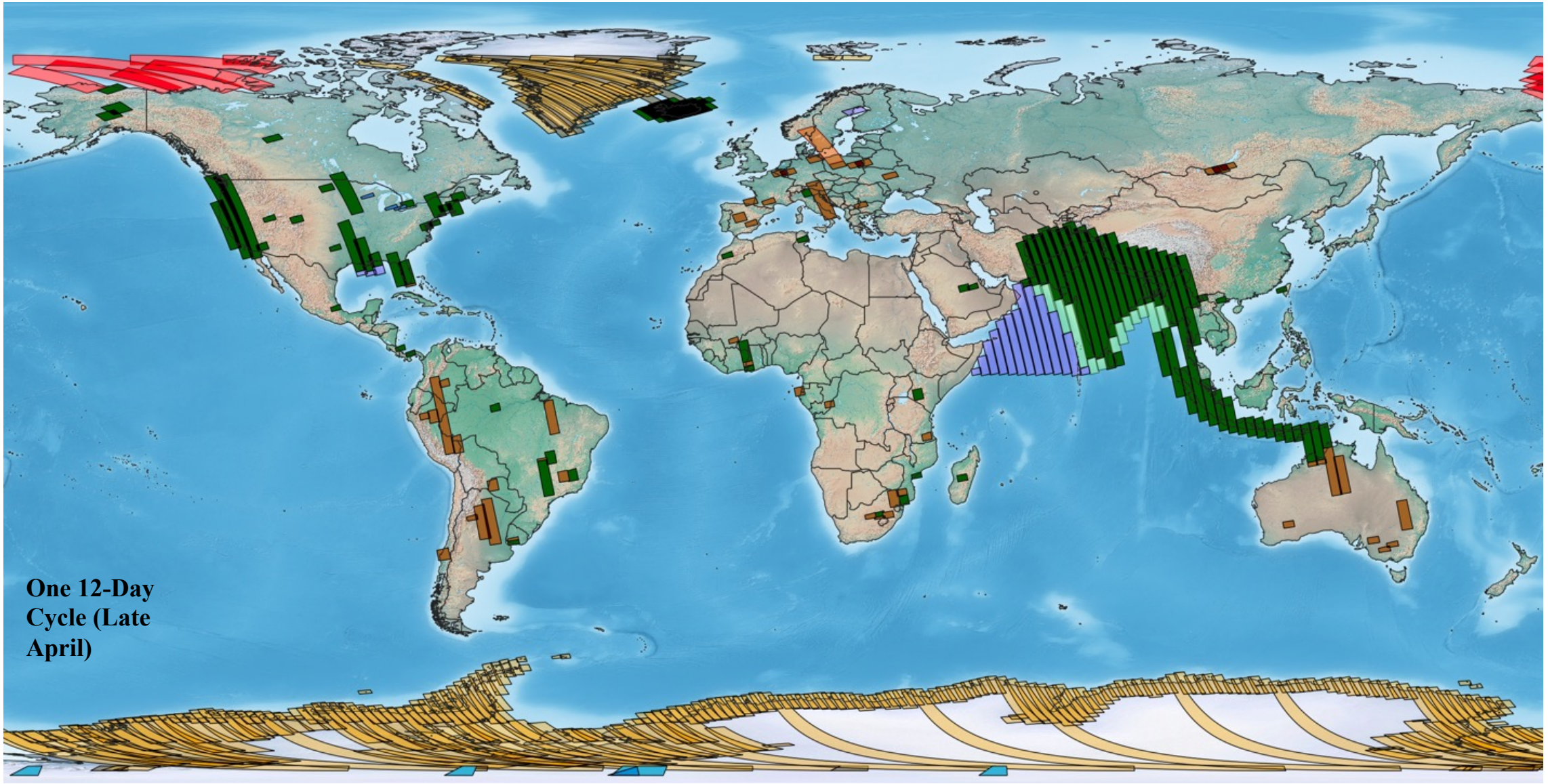
RSLC Posting

5 MHz ~ 25 x 5 m
20 MHz ~ 6.25 x 5 m
40 MHz ~ 3.12x 5 m
80 MHz ~ 1.56 x 5 m

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

S-SAR + L-SAR Coverage

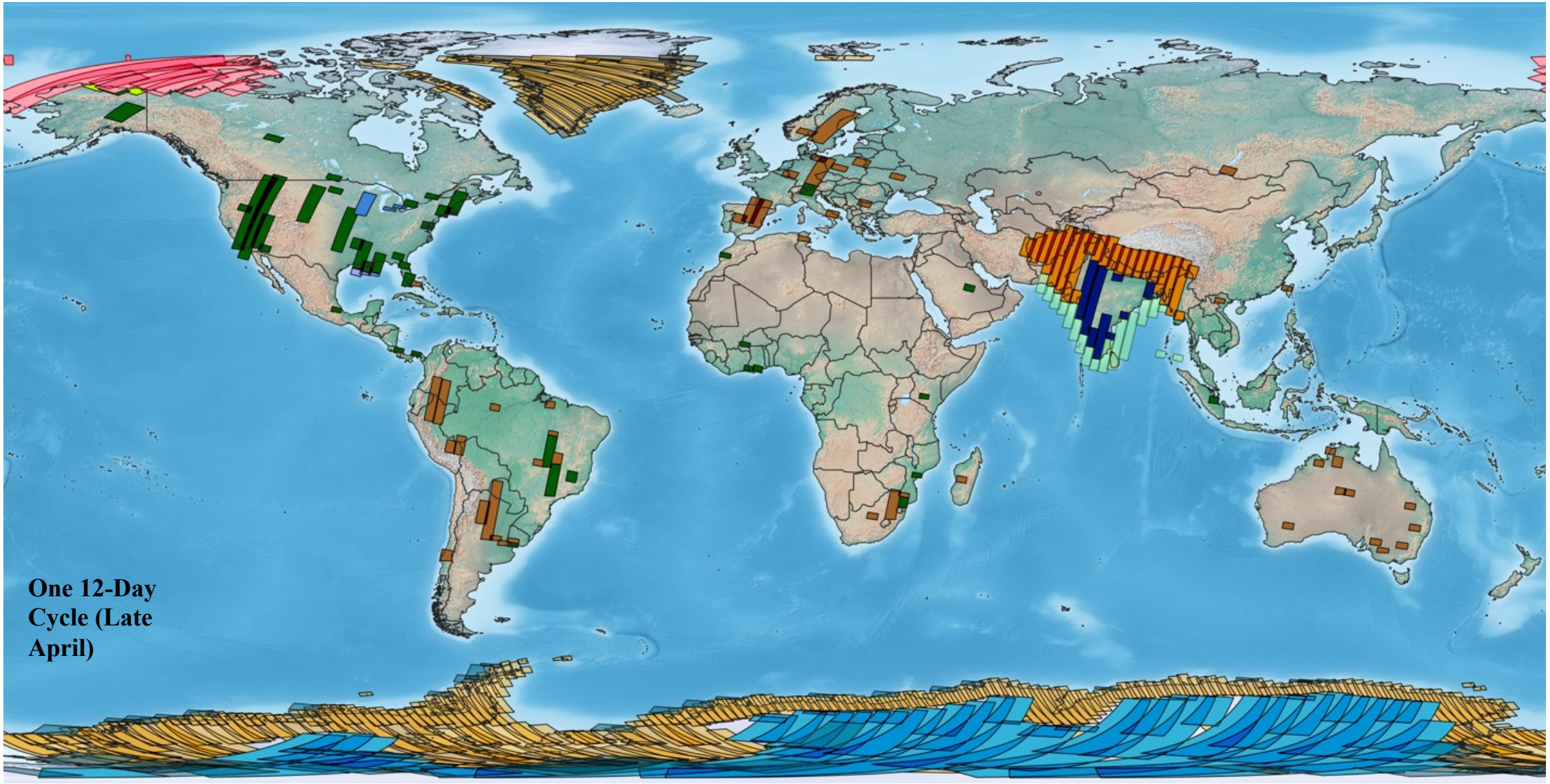
Planned Global Ascending for April



L-SAR is always co-collected with S-SAR

S-SAR + L-SAR Coverage

Planned Global Descending for April

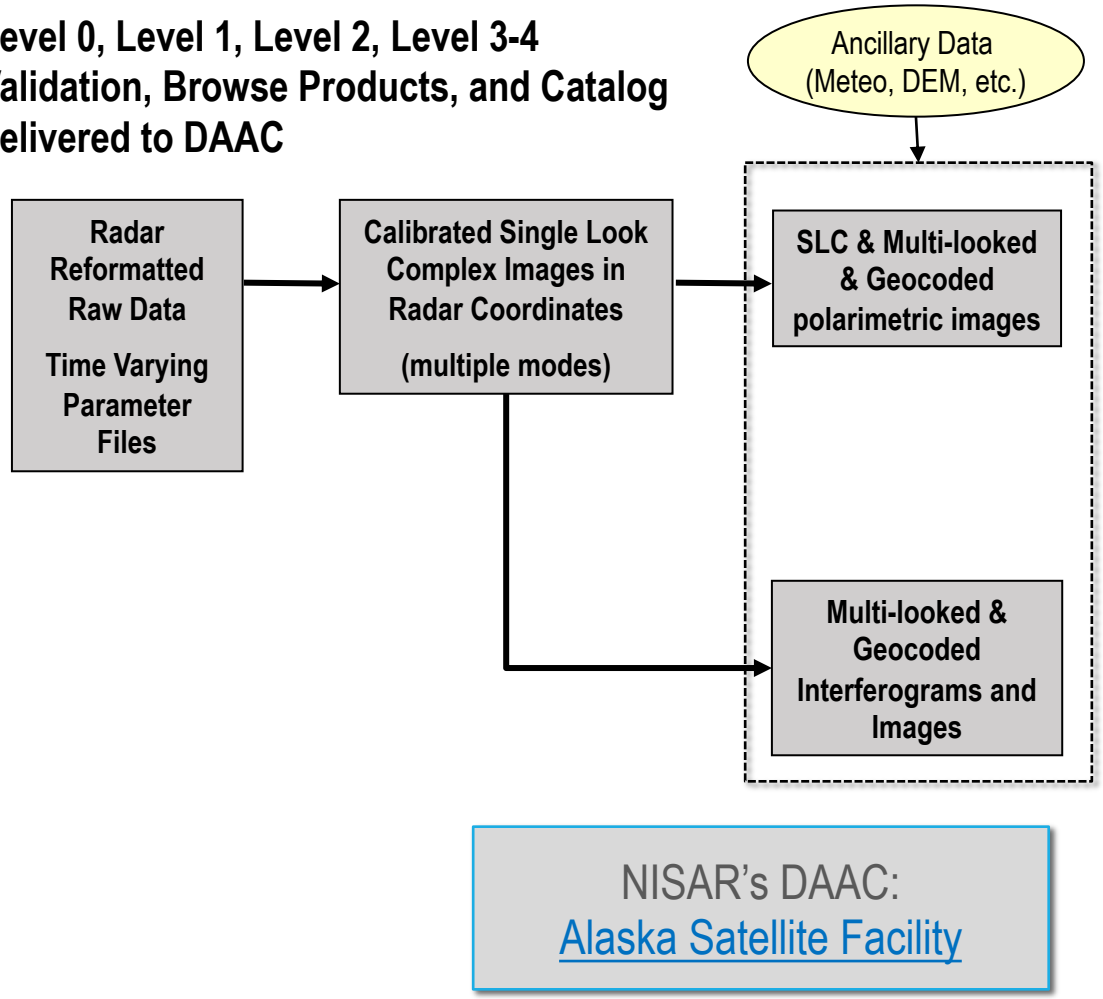


L-SAR is always co-collected with S-SAR

NISAR Level 0, 1, & 2 Product Overview

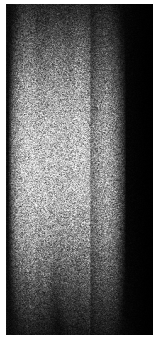
Level 0	Level 1	Level 2

Level 0, Level 1, Level 2, Level 3-4 Validation, Browse Products, and Catalog delivered to DAAC

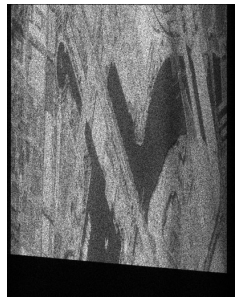


NISAR's DAAC:
Alaska Satellite Facility

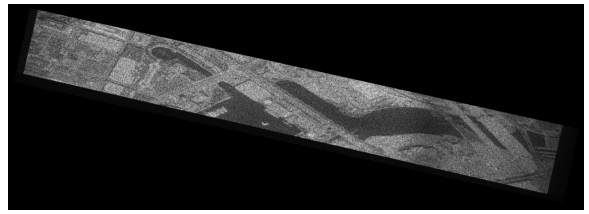
L0 - Raw



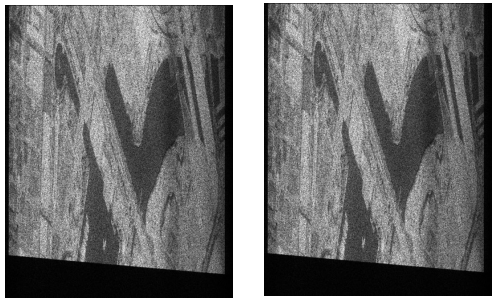
L1 – RSLC
Radar Coordinates



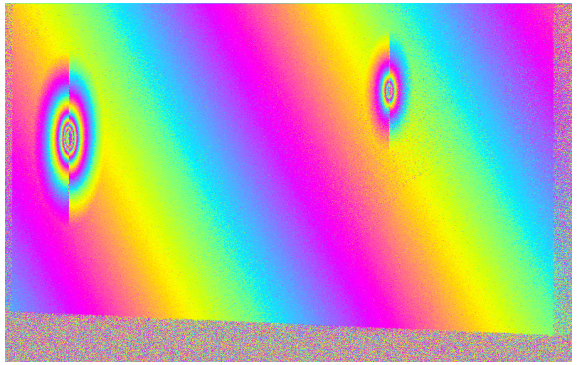
L2 – GSLC
Geocoded



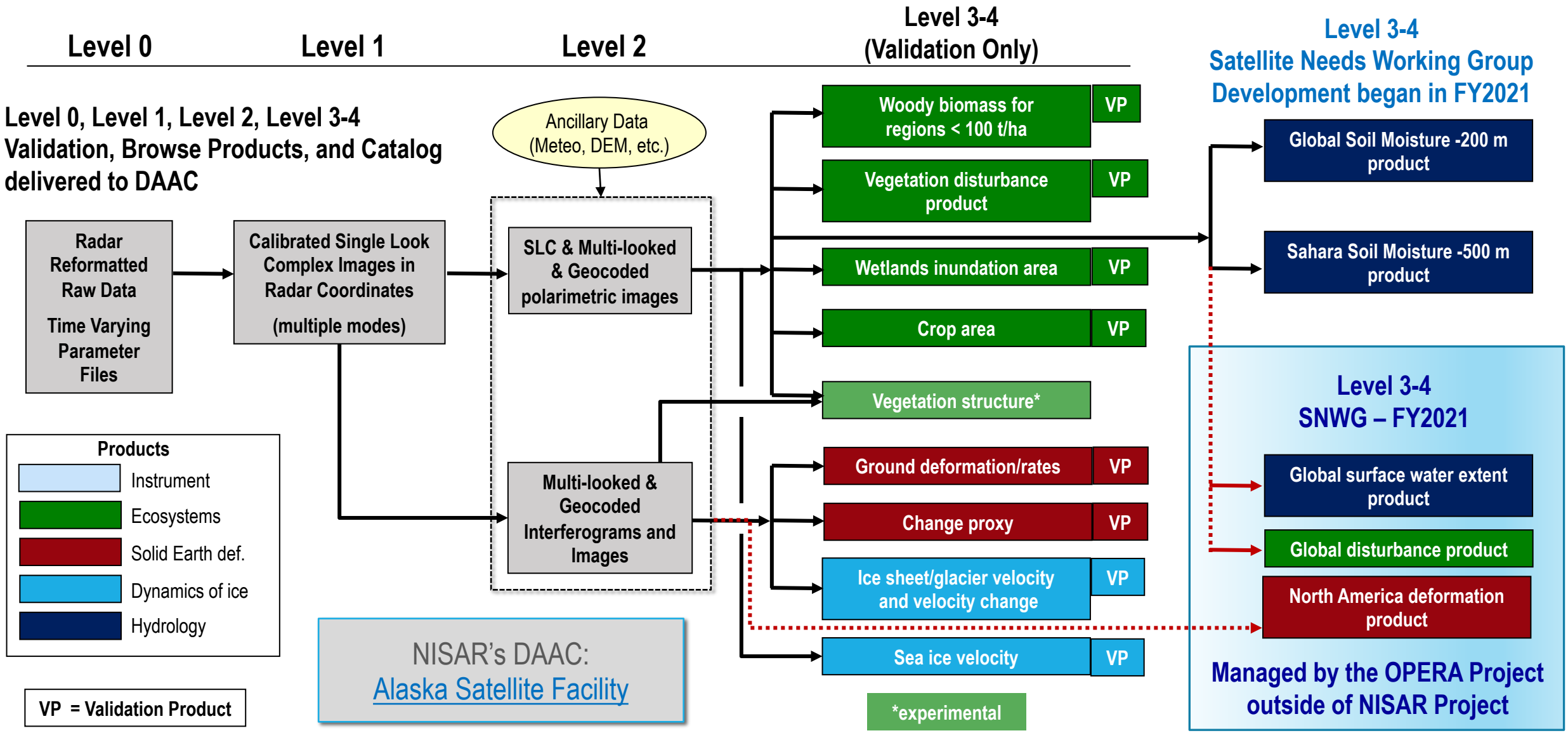
L1 – RSLC (time 1, 2)



L1 – RIFG



NISAR Science Data Analysis and Archive Approach



NISAR L2 SAR Products

Level 0	Level 1	Level 2

Level 0, Level 1, Level 2, Level 3-4 Validation, Browse Products, and Catalog delivered to DAAC

Ancillary Data (Meteo, DEM, etc.)

Radar Reformatted Raw Data

Time Varying Parameter Files

→ **Calibrated Single Look Complex Images in Radar Coordinates**

(multiple modes)

→ **SLC & Multi-looked & Geocoded polarimetric images**

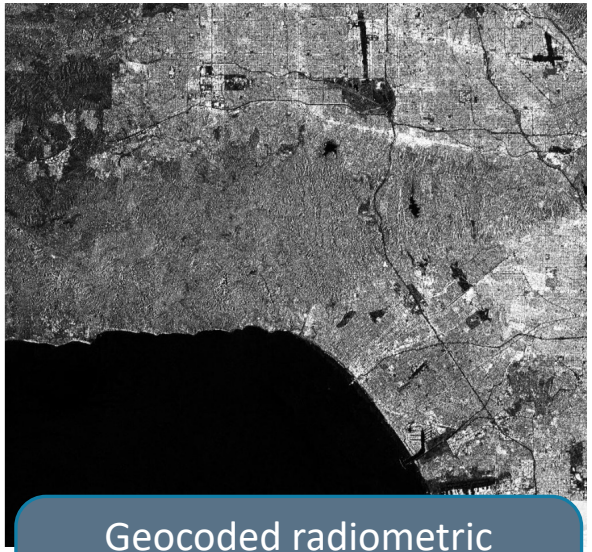
→

Geocoded RTC products (HH, HV) can be analyzed as another "optical" band

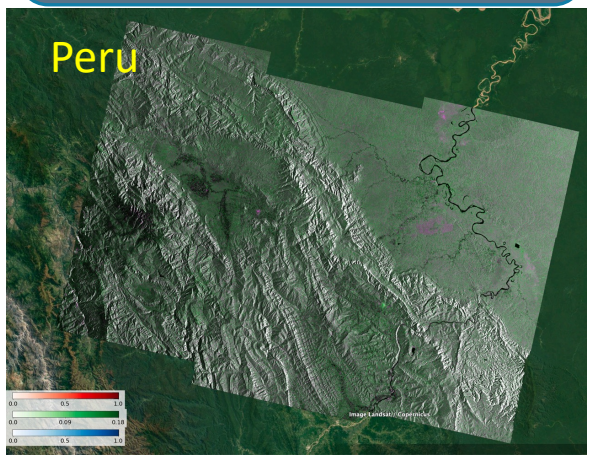
NISAR's DAAC:
Alaska Satellite Facility

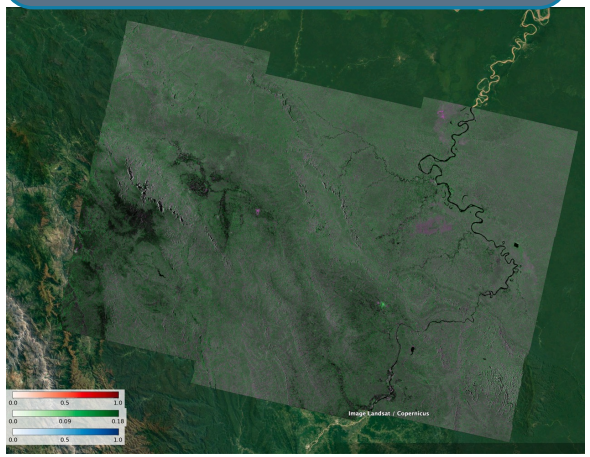


Geocoded Covariance (GCOV) Simulated NISAR from Sentinel-1 data



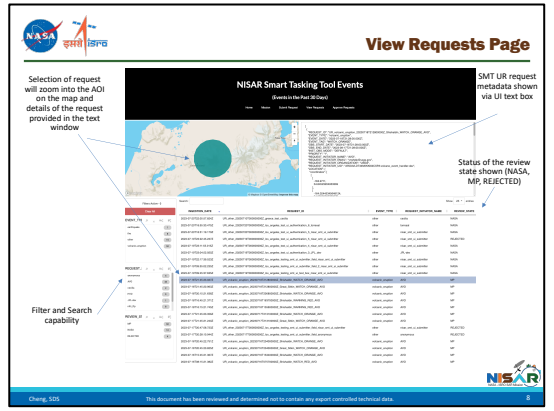
Geocoded radiometric terrain correction (RTC: GSLC) collected Sentinel-1 data





Urgent Response Tasking





- Standard NISAR Observations: 12, 24, 48 hours L-0, L-1, L-2 products
- Automated Tasking - Global Earthquake
- Automated Tasking - Global Volcanic Unrest
- Tasking Requests – NASA's Disaster Response Coordination System
- Tasking Requests – Credentialed Agency Member

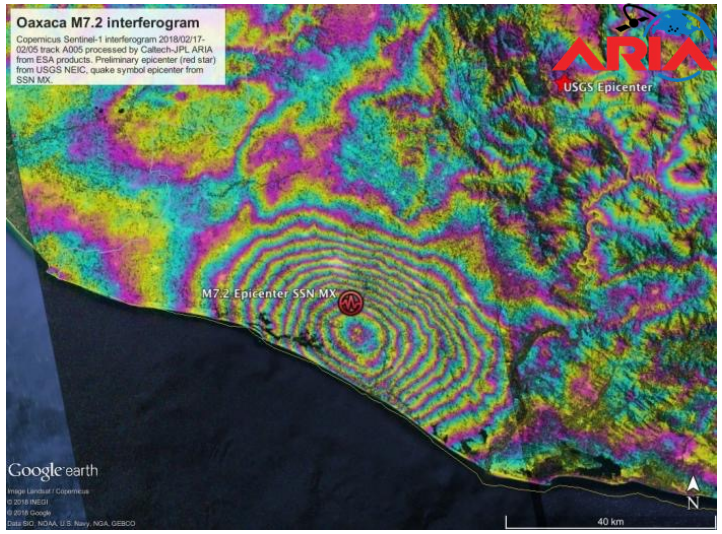
Automated Tasking For Earthquakes and Volcanic Unrest

Earthquakes

A NISAR Urgent Response request is submitted if any one of the 3 criteria are met:

1. USGS PAGER level is Red or Orange
2. PAGER level is Yellow and *in US or India
3. Earthquake in US or India that is >= 7.0 magnitude and < 50 km in depth

*The definition of “in” is when an earthquake AOI (with a 240 KM radius) intersects the USA or India.

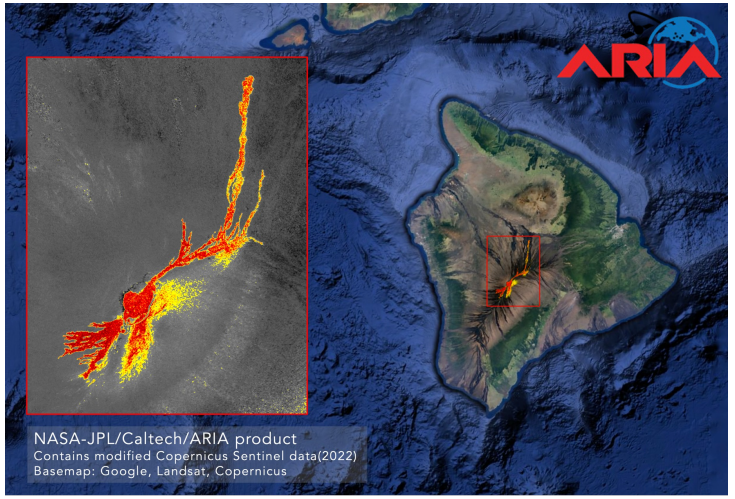


Oaxaca Mexico Earthquake 2018

Volcanic Unrest

A NISAR Urgent Response request is submitted if the USGS VNS Aviation color is Red or Orange issued by:

U.S. Volcano Observatories: Alaska (AVO), California (CalVO), Cascades (CVO), Hawaiian (HVO), Northern Marianas Islands (NMI) and Yellowstone (YVO).



Mauna Loa Eruption 2021

Key Considerations for UR Requests

Tasking Considerations:

- NISAR will collect data over all land and all ice targets on every orbit.
- Ocean disasters (outside of US waters) such as oil spills and hurricanes may not be covered with the science observation plan.
- It may be days before NISAR is over the disaster area

Downlink prioritization: First collected ➔ first downlinked, unless identified as Urgent Response (UR)

- Most NISAR data will be downlinked within 5-7 hours from collection.
- *In most cases,* ***UR downlinke will be only be about 2 hours quicker*** *than with standard downlink priority*

Rapid Ground System data and product processing: UR data/products will be processed to a lower quality to improve latency and will be replaced with science quality products once generated.

Manual Urgent Response Request

Two Pathways to Request NISAR Urgent Response Data

A. **ICGS-SAR/CEOS Agencies** can submit a request to NASA's Disasters Response Coordination System (DRCS: drcs@mail.nasa.gov) and they will submit a NISAR request on your behalf.

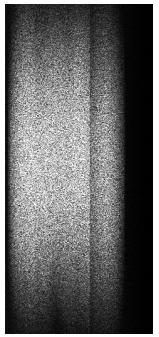
B. **NISAR Credentialed Agency Members** submit data requests on behalf of their agencies.

- USGS and NOAA have active SAR/InSAR programs that will immediately benefit from the lower latency data and products.
  - They identified a NISAR POC and people (primary and alternate) for the their disaster response categories (i.e. earthquakes, volcanoes, hurricanes, etc.)
- *Agencies that demonstrate the need for NISAR Urgent Response data multiple times a year and are able to directly process/analyze SAR/InSAR data/products may request to become credentialed by emailing* Gerald.Bawden@nasa.gov

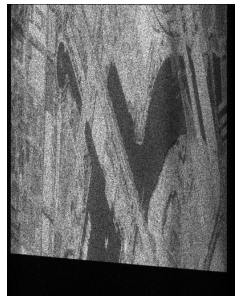
Science Data System Product Latency

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

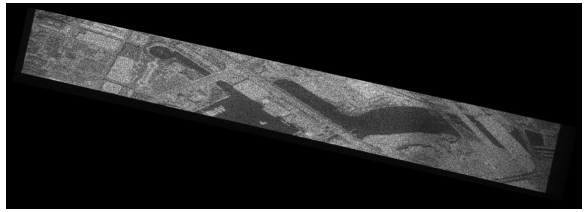
L0 - Raw

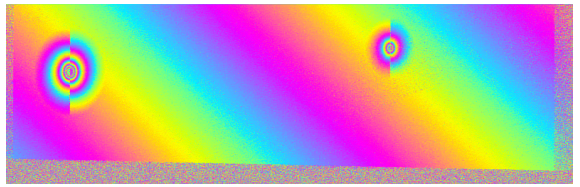


L1 - RSLC



L2 - GSLC

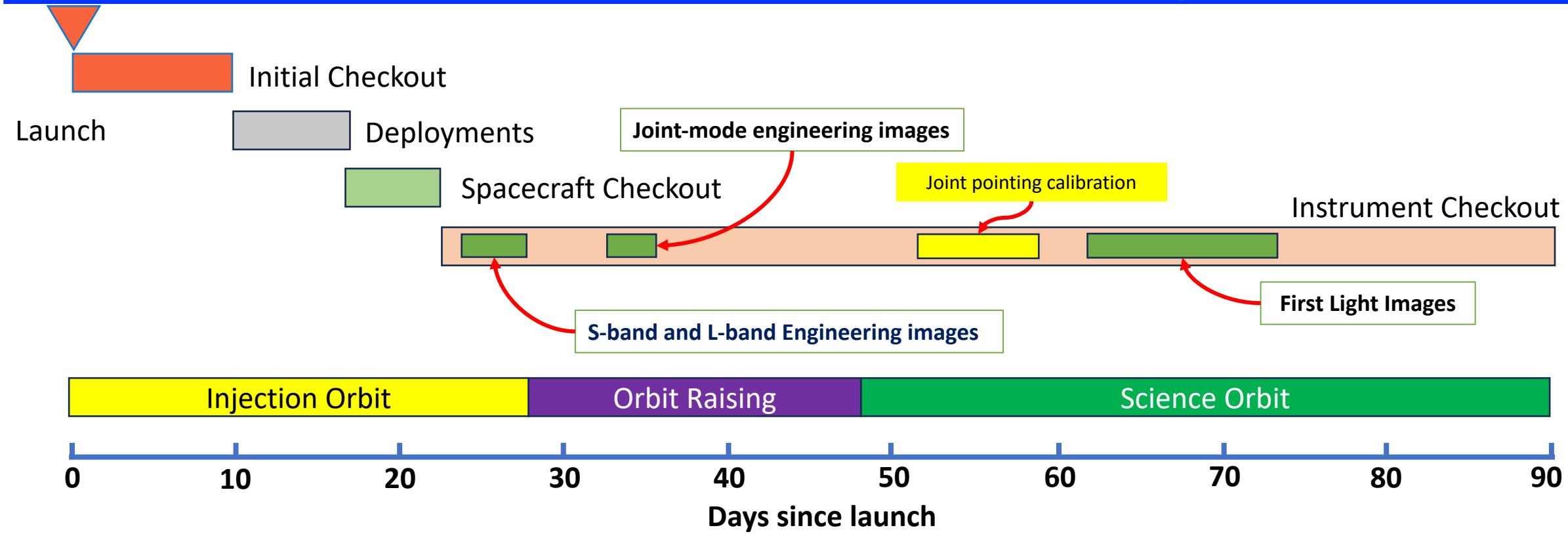




- Science Data System is sized to produce this data within 1 day latency
- Limiting factor with Urgent Response data is receiving all the ancillary files, specifically the Medium accuracy Orbit Ephemeris from GNSS

Commissioning Plan

Days since launch



- First light images 2-3 months after launch
- Science operations 3 months after launch

- Global products to Level 2 will be fully and openly available to the global community
- NISAR data/products @ Alaska Satellite Facility
  - https://nisar.jpl.nasa.gov
  - https://asf.alaska.edu/

SDC – Repeat-pass InSAR after NISAR
Phase A start uncertain

EARTH SYSTEM OBSERVATORY

LD
Low Duty-Cycle

MS
Multi-squint

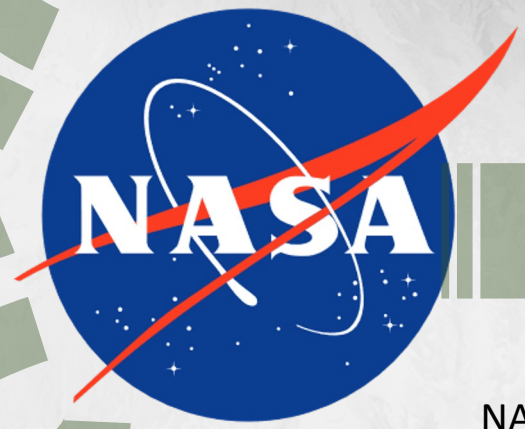
RL
ROSE-L Augmentation

SD
Sub-Daily

SS
Split-Swath

September 2023 NASA HQ Guidance:
- **Complete architecture trade study in mid-2024**
- **Continue NISAR lessons learned planned activities**
- **Continue collaboration study with ESA on ROSE-L**

Study Recommendation
End of FY25

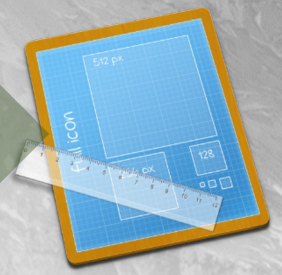




NASA dispositions SDC with respect to Decadal Survey
FY26



Decadal Survey
FY27



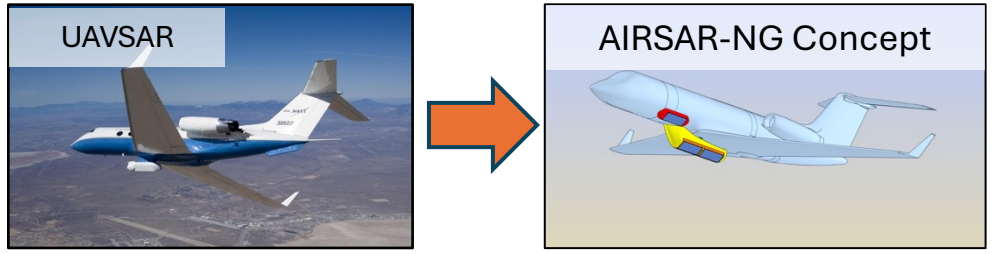
SDC
Mission Concept Review
FY27-FY28

SDC Architecture Recommendation Goals:
- **Lay the groundwork to facilitate NASA decisions**
- **Position support for SDC confirmation in the 2027 Decadal Survey**
- **Determine if geodetic or phase + backscatter is best fit**

G-IV AIRSAR-NexGen

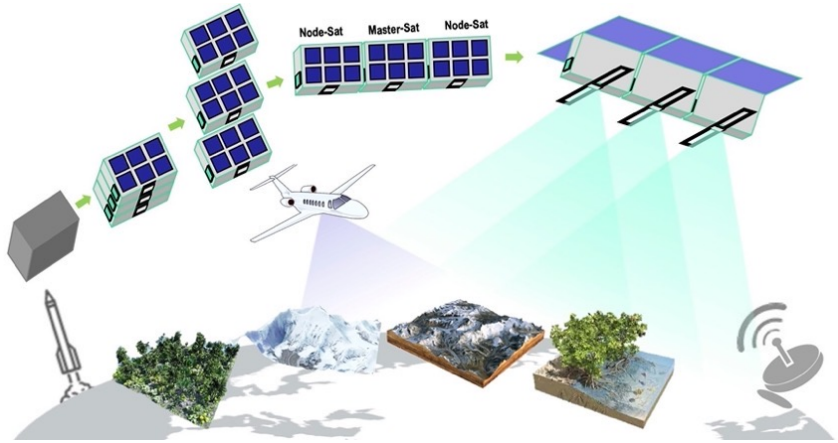
- Maintain current capabilities of UAVSAR (P, L, Ka-band)
- Simultaneous P- and L-band repeat-pass PolInSAR for vegetation structure and soil moisture studies
- Option for simultaneous L- and S-band repeat-pass PolInSAR to simulate/cross-calibrate with NISAR
- Option to add stereo optical imager
- Ability to support bistatic/multi-static observations

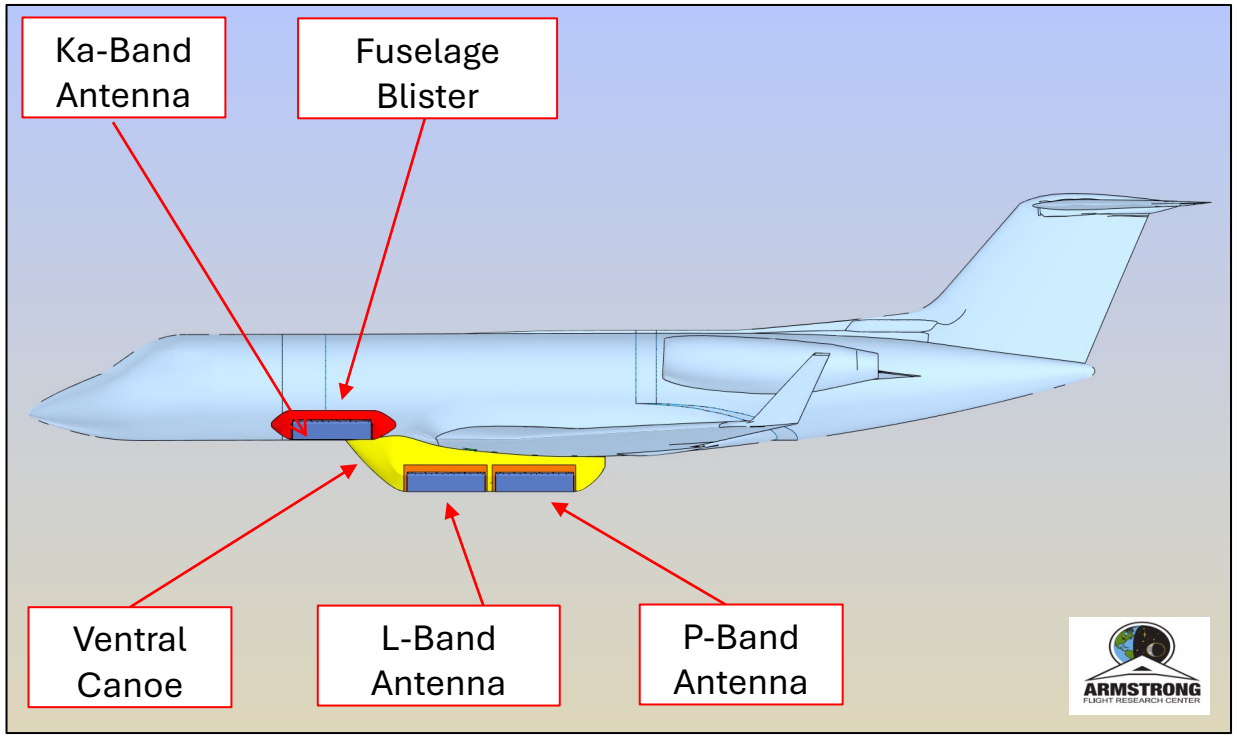
Orange indicates new capabilities



G-III G-IV

*Leveraging **FlexDSAR IIP** for new digital beamforming electronics but reuse existing RF components & antennas where possible*





AfriSAR-2024

ESA/DLR & NASA's P + L band Airborne Campaigns

Selecting sites that will benefit both NASA (NISAR) and ESA (BIOMASS) science communities

- DLR Collected data summer 2023. A coup d'état in Gabon delayed UAVSAR until Summer of 2024.
- Leverage AfriSAR-2016 by using **Gabon as Base Ops for West Africa sites** to continue to foster a good working relationship with AGEOS (Gabonese Earth Observing Agency)
- Select sites with **good ground and lidar data** so that they can be used for validation; these sites will be used for **BIOMASS and/or NISAR cal/val**
- Seek to understand the strengths and limitations of BIOMASS and NISAR at a wide variety of sites that test the upper limits of NISAR (L-band) and the lower limits of BIOMASS (P-band) to measurement sensitivity to vegetation.



UAVSAR L- band SAR swaths

UAVSAR P- band SAR swaths

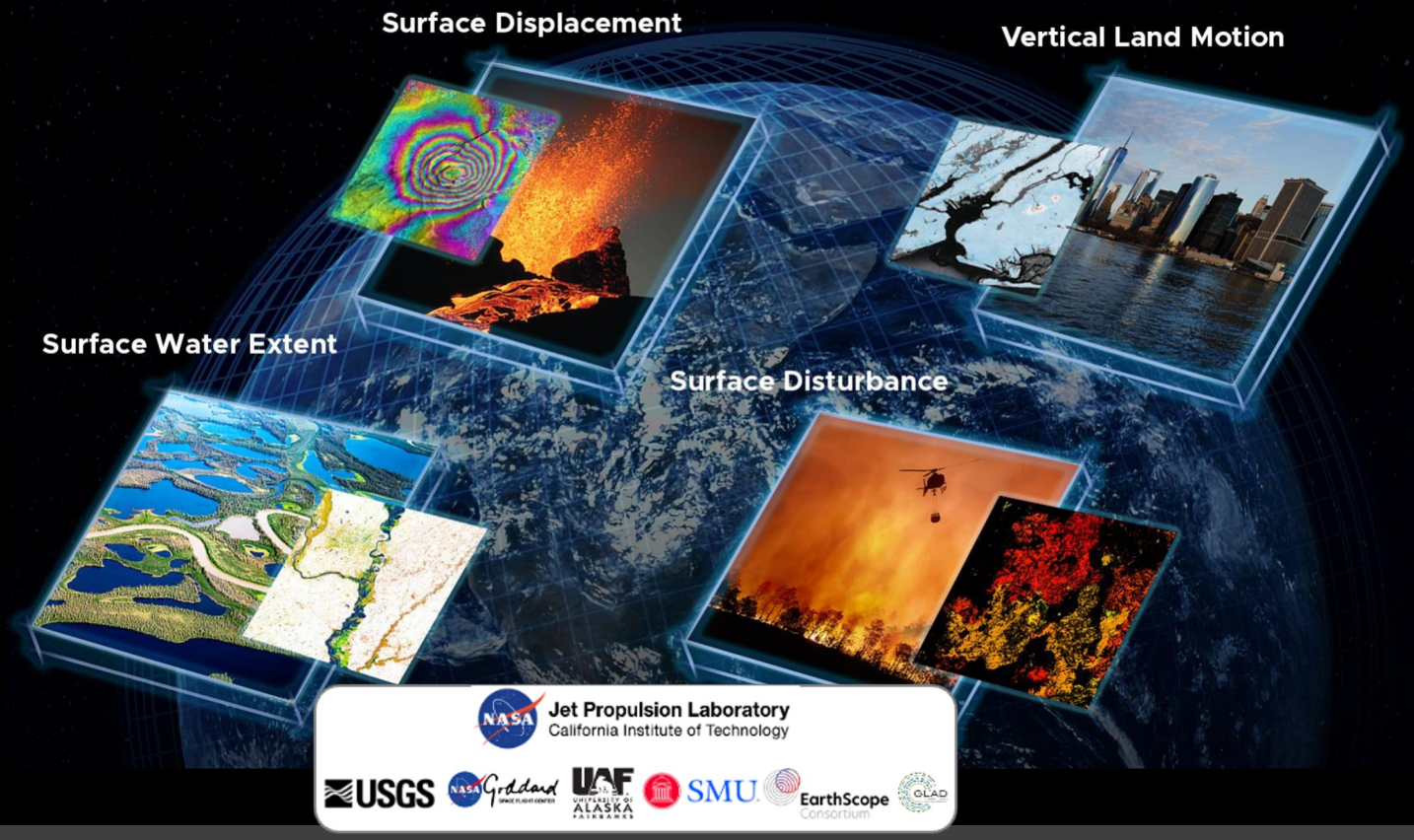
- Gabon flight lines repeated DLR's campaign
- DLR's corner reflector remained in Gabon to cross calibrate with UAVSAR (P- and L- band)

UAVSAR 2016 and 2024 L-band data are available at uavsar.jpl.nasa.gov

UAVSAR 2024 P-band data will be released shortly (after reprocessing)

OPERA Enabling End-Users to Take Action

Observation Products for End-users from Remote sensing Analysis



- **<u>Free and open</u> Analysis Ready Data** products designed for science and application stakeholders.
- 5 product lines in production
- ***New** since last science highlights:*
  - ***Sentinel-1 (radar) Surface Water product in production.***
  - ***OPERA funded for creation of a Vertical Land Motion Product***

OPERA is spearheading an innovative model within NASA that goes beyond a single mission (Landsat 8/9, Sentinel-1/2, NISAR) to develop multiple product lines

This document has been reviewed and determined not to contain export controlled technical data





ICGS-SAR

INTERNATIONAL COORDINATION GROUP FOR SPACEBORNE SAR MISSIONS

Japan – November 2024





ArcGIS StoryMaps

https://nisar.jpl.nasa.gov/applications/arcgis-storymaps/

Thank You

Dr. Gerald Bawden

Program Scientist/Manager

NISAR/SDC/UAVSAR/OASIS/

OPERA/ASF

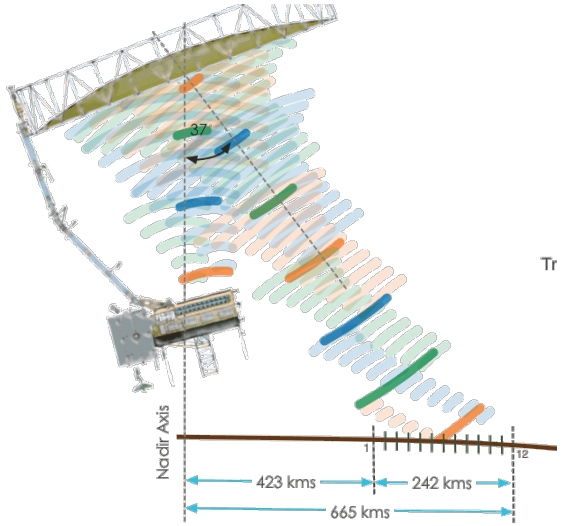
NASA Headquarters

Backup slides

NISAR Science and Earth Action

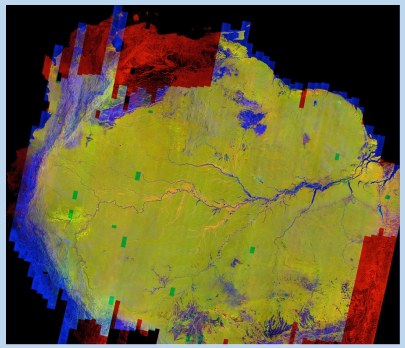
Understanding Climate, Carbon, and Catastrophic Change
Resource Management + More

- Response of ice sheets to climate change and the interaction of sea ice and climate
- Carbon storage and uptake dynamics in wooded, agricultural, wetland, and permafrost systems
- Earthquake, volcanic, and landslide cycles, exploring potentials for urgent response and hazard mitigation
- Dynamics of water, hydrocarbon, and sequestered CO_2 reservoirs
- Supports dozens of applications



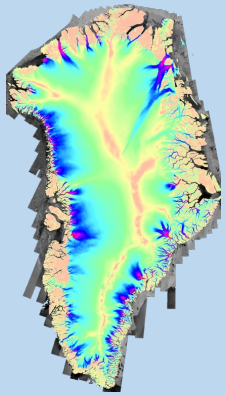
- Global Analysis Ready Synthetic Aperture Radar Data
- Geocoded, terrain corrected, polarimetric products
- Geocoded interferometric products

Global Biomass Dynamics



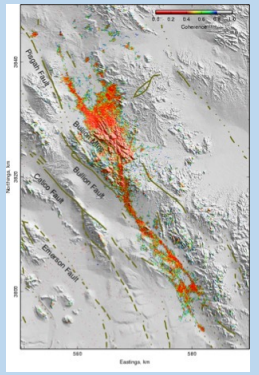
Amazonia

Global Ice Dynamics



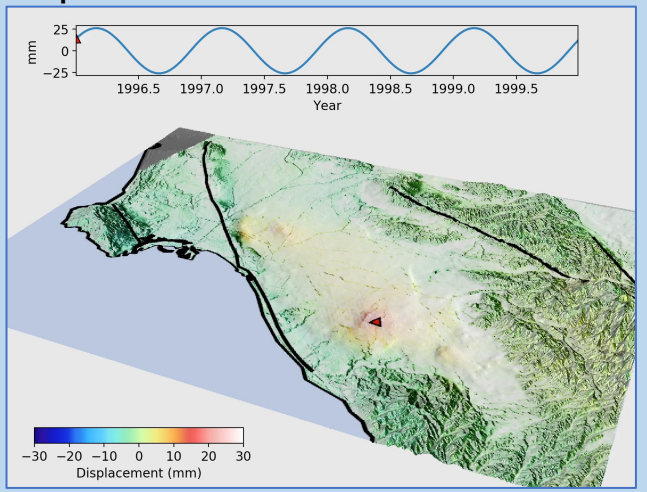
Greenland

Global Hazards



Earthquake damage

Aquifer Health



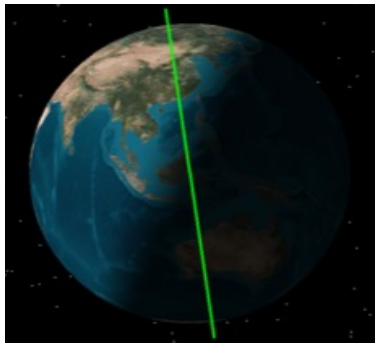
Agriculture



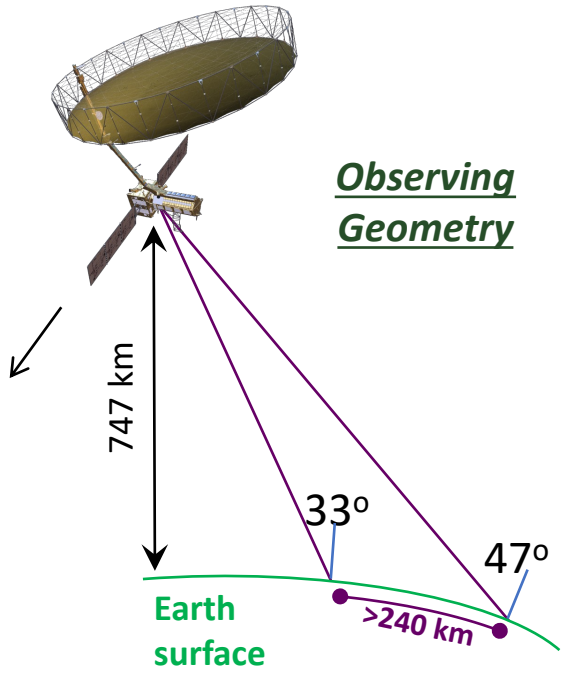
NISAR Science Observation Summary

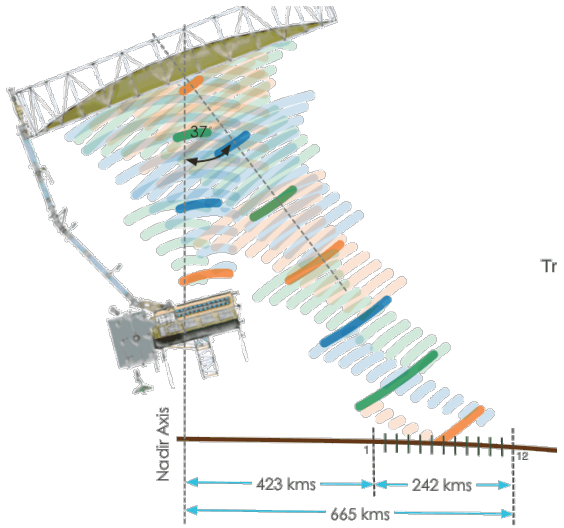
NISAR Characteristic:	Would Enable:
L-band (24 cm wavelength)	Low temporal decorrelation and foliage penetration
S-band (9.4 cm wavelength)	Sensitivity to light vegetation
SweepSAR technique with Imaging Swath > 240 km	Global data collection
Polarimetry (Single/Dual/Quad)	Surface characterization and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



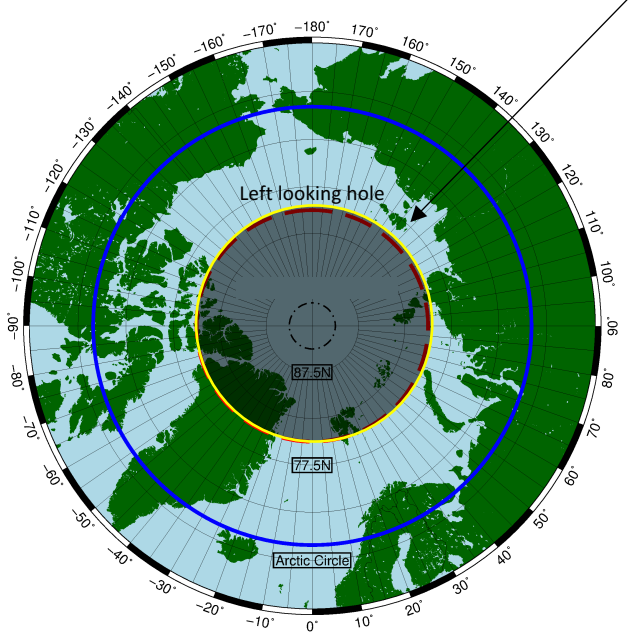


6 AM / 6 PM



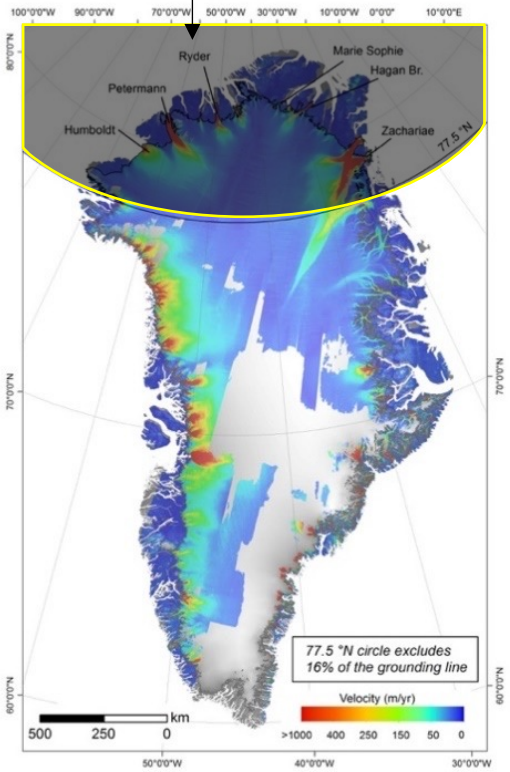


NISAR Coverage between 77.5° N and 87.5° S



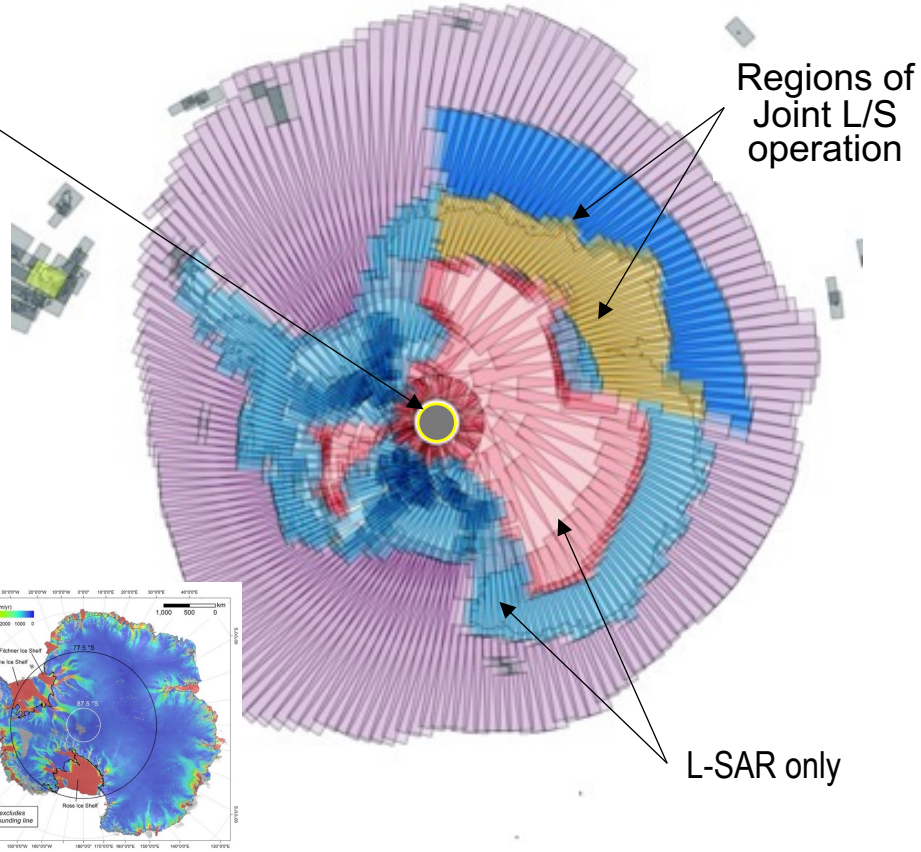
NISAR will image to 77.5°N in the Acrtic

Area without NISAR coverage



NISAR will not image Northern most part of Greenland

Different Antarctica collection modes



A plan to fill the Antarctica pole hole a few will be considered after launch.

SDC: Repeat-pass InSAR after NISAR

EARTH SYSTEM OBSERVATORY

NASA Direction: Serve stakeholders in the following science communities according to the SATM:



SDC Observation Goals in Decadal Survey:

- Interferometric repeat-pass SAR at sub-weekly to daily rates.
- Resolution needs ranging from 5m to 15m
- Sensitivity to height changes between 1-10 mm
- Time series measurements from 1 mm/week to 1 mm/year
- Continuous global monitoring of all land and coastal areas
- Supplement the program of record running from 2017-2027
- Provide a plan for a 10+ year mission lifetime
- Maximum cost to NASA of $500M (Phase A-F)

Explicit NASA-specified SDC Observation Goals:

- Explore SAR radiometry, not only interferometry, in architectures to enable the wider range of science and applications identified in the DS
- Noise equivalent sigma-0 < -20 dB
- Ambiguities < -20 dB