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# SAR Satellites including the NASA-ISRO SAR Mission


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# Classic SAR satellites

| | repeat cycle (days) | wave-length (cm) |
|---|---|---|
| European ERS-1/ERS-2 '92-'01(-2011) | 35 (1,3,183) | 6 |
| Canadian Radarsat-1 1995-2013 | 24 | 6 |
| European Envisat '03-Sep.'10('10-Apr.'12) | 35 (30) | 6 |
| Japanese ALOS Jan. 2006–Apr. 2011 | 46 | 24 |
| German TerraSAR-X '07, TanDEM-X '10 | 11 | 3 |
| Italian COSMO-SkyMed 4x launch '07-'10 | 16 (1,4,7,8) | 3 |
| Canadian Radarsat-2 launched Dec. 2007 | 24 | 6 |

# SAR satellites processing

| | Modes | ISCE2 proc. |
|---|---|---|
| ERS-1/ERS-2 | 1 strip map | yes raw, SLC |
| RADARSAT-1 | 7 standard strip<br>5 fine strip<br>ScanSAR | strip: maybe CEOS raw<br>ScanSAR: no |
| Envisat | 7 standard strip (IM)<br>ScanSAR (WS) | strip: yes raw, SLC<br>ScanSAR: no |
| ALOS | strip FBS, FBD, POL<br>ScanSAR | strip: yes raw, SLC<br>ScanSAR: no |
| TerraSAR-X, PAZ | strip<br>ScanSAR<br>Spotlight | strip: SLC<br>ScanSAR: no<br>Spotlight: SLC |
| COSMO/SkyMed | strip, ScanSAR, Spotlight | strip: raw, SLC<br>Spotlight: SLC |
| RADARSAT-2 | strip (4 types), ScanSAR, Spotlight | strip: SLC<br>Spotlight: ? |

# other SAR spacecraft

| | repeat cycle (days) | wave-length (cm) |
|---|---|---|
| US SeaSat 1978 (110 days) | 17/3 | 24 |
| Japanese JERS-1 1992-1998 | 44 | 24 |
| US Shuttle Imaging Radar–C (SIR-C) 1994 (2x 10-day flights) | 1 day, 6 months | 3, 6, 24 |

# new SAR spacecraft

| satellite (launch or planned) | repeat cycle (days) | wave-length (cm) |
|---|---|---|
| Copernicus Sentinel-1 (A: Apr. 2014, B: Apr. 2016–Dec. 2021, C: 2024?) | 12(6) | 6 |
| Japanese ALOS-2 (May 2014) | 14 | 24 |
| Indian RISAT-1 (Apr. 2012) | 25 | 6 |
| NASA-ISRO SAR (NISAR) mission (2024) | 12 | 12,24 |

# New SAR satellites processing

| | Modes | ISCE2 proc. |
|---|---|---|
| Sentinel-1A, B, C | stripmap<br>TOPS | strip: SLC (raw extra work)<br>TOPS: SLC (topsApp.py) |
| ALOS-2<br>(alos2App.py, alosStack) | strip (3 types)<br>ScanSAR<br>Spotlight | strip: SLC<br>ScanSAR: full-aperture SLC<br>Spotlight: SLC |
| RISAT-1 | stripmap<br>ScanSAR | strip: SLC, raw extra work<br>ScanSAR: no |

# new SAR spacecraft

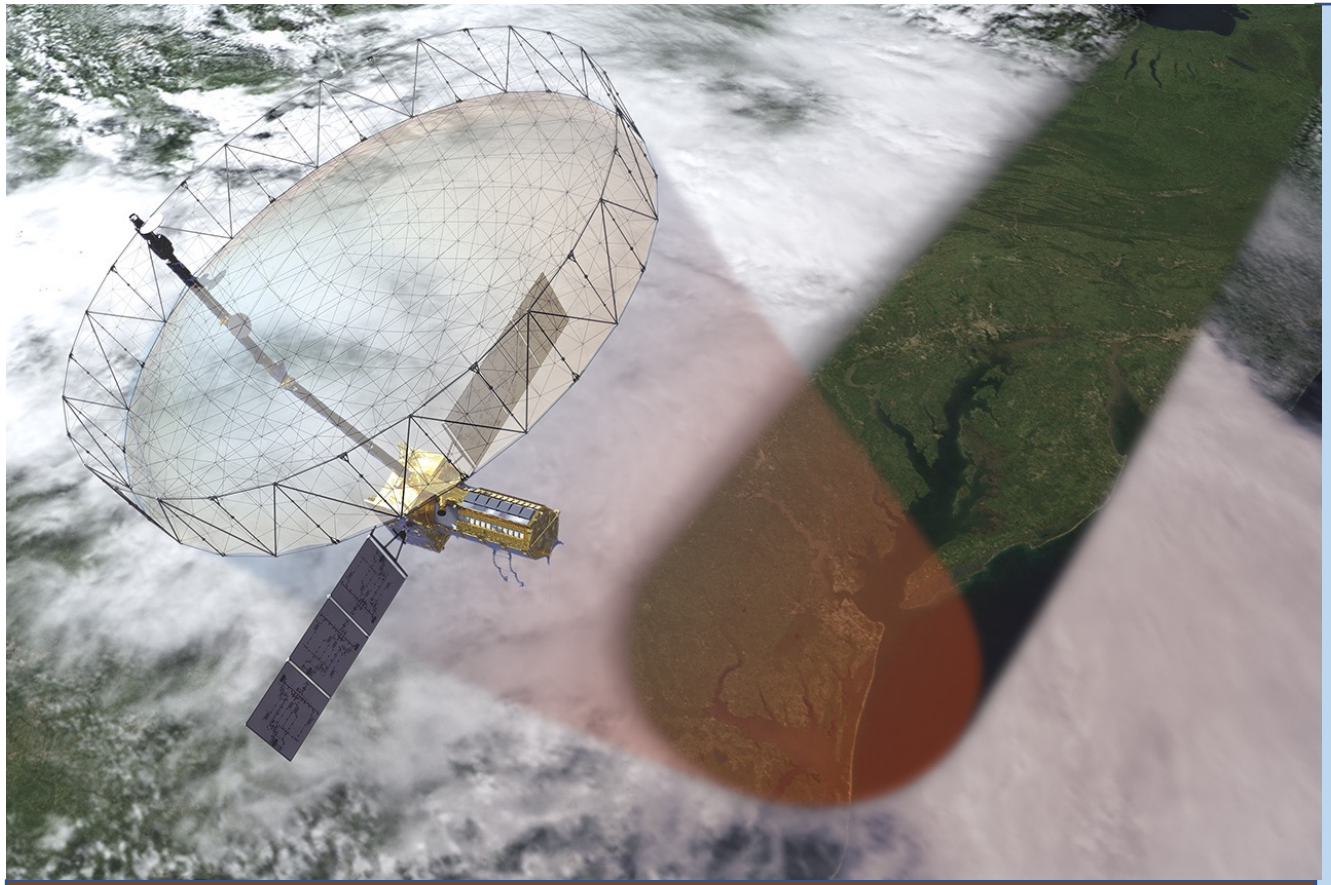
| satellite (launch or planned) | repeat cycle (days) | wave-length (cm) |
|---|---|---|
| Argentina SAOCOM-1 (A: Oct. 2018, B: Aug. 2020) | 16(8) | 24 |
| Japanese ALOS-4 (Mar. 2024?) | 14 | 24 |
| Italian COSMO-SkyMed 2nd Gen. (1: Dec. 2019, 2: Jan. 2022, 3:, 4:) | N/A | 3 |
| Canadian RADARSAT Constellation Mission 3x (Jun. 2019) | 4 | 6 |

# More new SAR spacecraft

| satellite (launch or planned) | repeat cycle (days) | wave-length (cm) |
|---|---|---|
| South Korea KompSat-5 (2013-2022) | 16(8) | 3 |
| Spanish PAZ (clone TerraSAR-X) (Feb. 2018) | 11 (4,7) | 3 |
| Capella-1 through -n (2018–present) | N/A | 3 |
| ICEYE ~16 satellites now (Aug. 2023)<br>some satellites have 1-day separation | 1 | 3 |

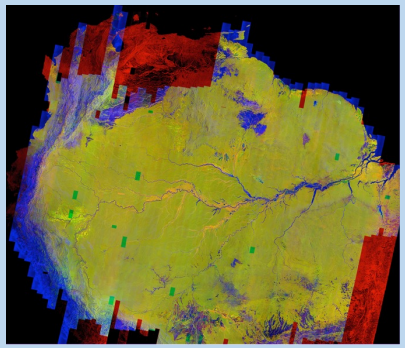
# NISAR Science and Applications

## Understanding Climate, Carbon, and Catastrophic Change
## Resource Management



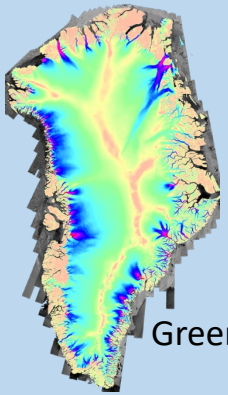
Global systematic, all-weather, day-night, time-series measurements of surface deformation and change

### Global Biomass Dynamics



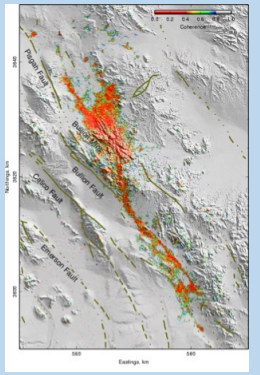
Amazonia

### Global Ice Dynamics



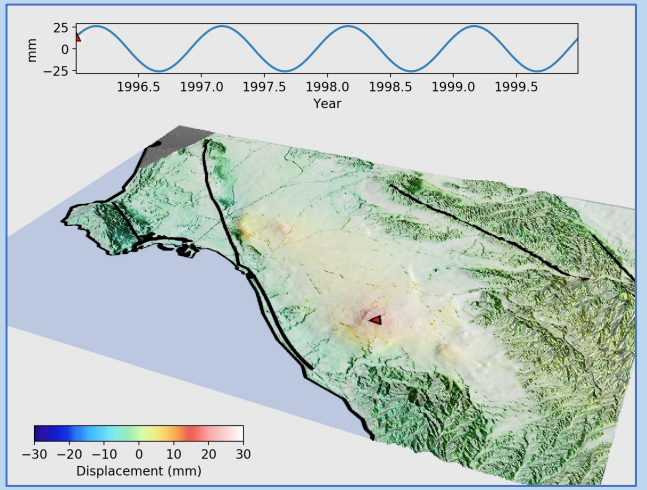
Greenland

### Global Hazards



Earthquake damage

### Aquifer Health




### Agriculture

# It is time to get ready

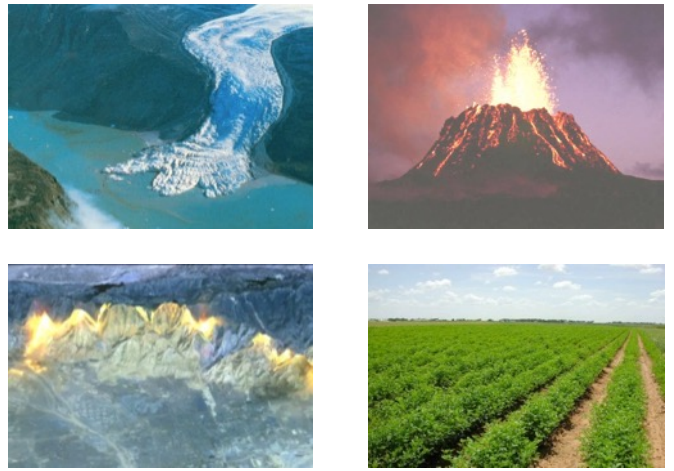

- NISAR is in its final phase of integration
- Launch planned for early 2024
- First light images 2-3 months after launch
- Science operations 3 months after launch
- Global products to Level 2 will be fully and openly available to the global community
- Broad scientific and applied uses
- Cloud-based data, tools and services will facilitate access and use

For more information: ***https://nisar.jpl.nasa.gov***

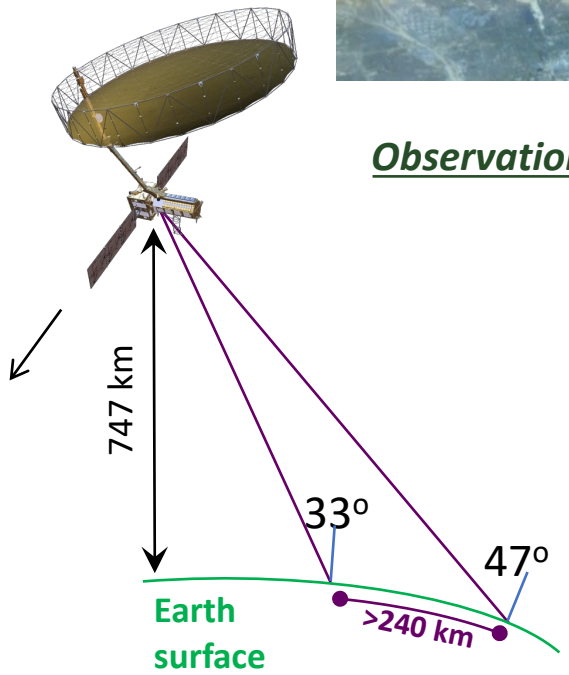
# NISAR Science Observation Summary

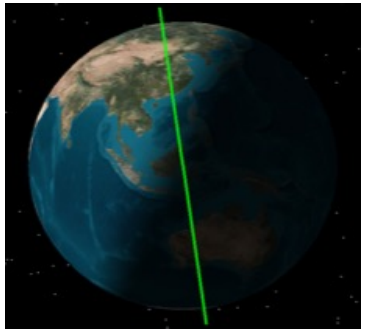
| NISAR Characteristic: | Would Enable: |
|---|---|
| L-band (24 cm wavelength) | Low temporal decorrelation and foliage penetration |
| S-band (9.4 cm wavelength) | Sensitivity to light vegetation |
| SweepSAR technique with Imaging Swath > 240 km | Global data collection |
| Polarimetry (Single/Dual/Quad)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

**NISAR Will Uniquely Capture the Earth in Motion**



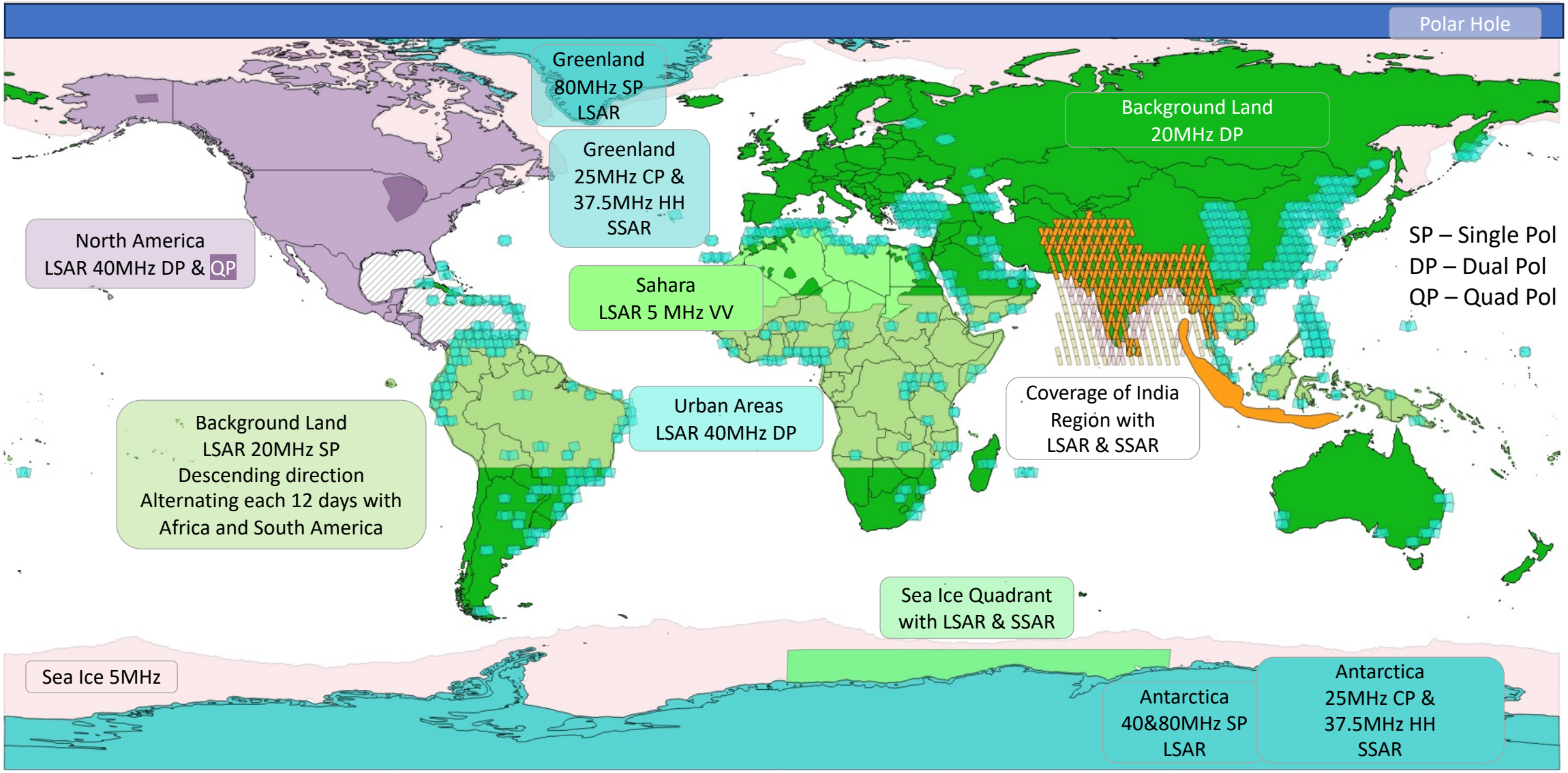
***Observation Geometry***



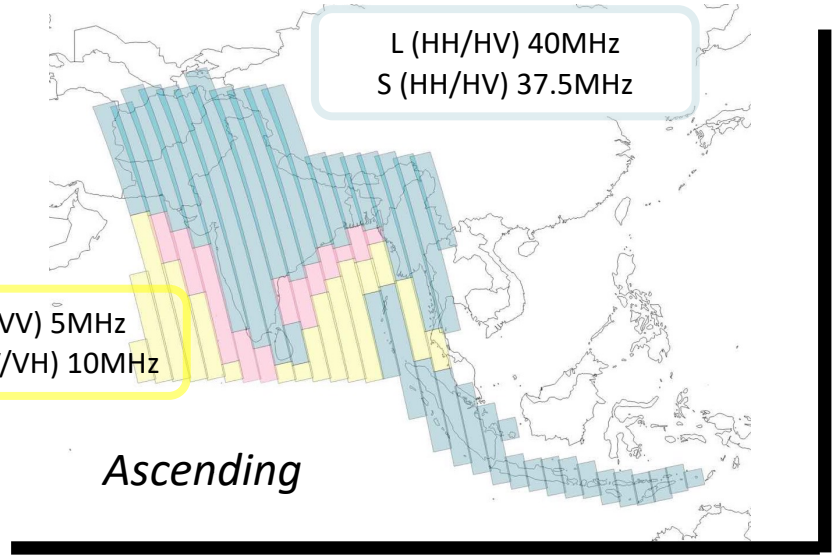



6 AM / 6 PM

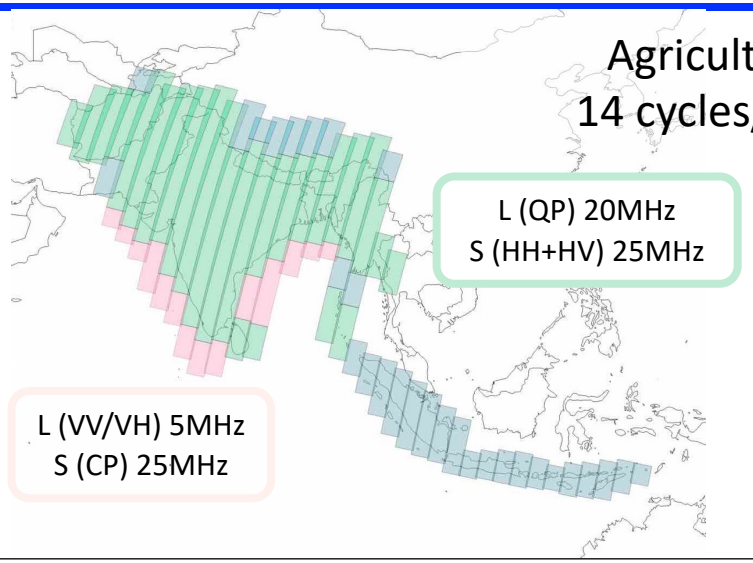
# Current Observation Plan
# Revised every 6 months

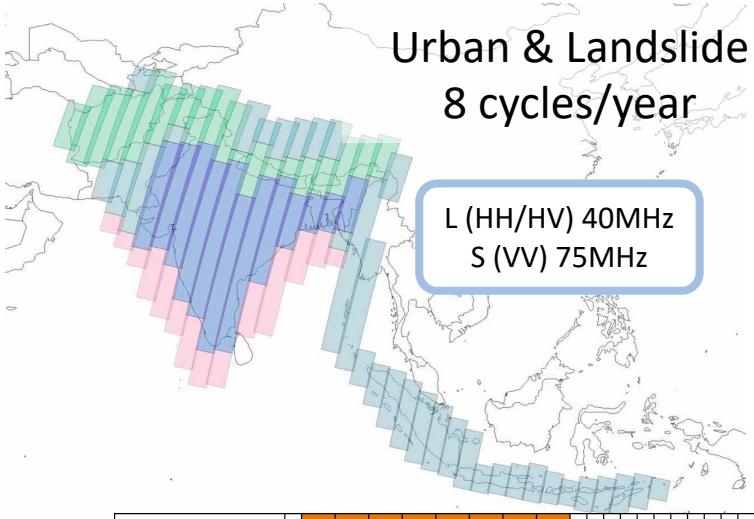


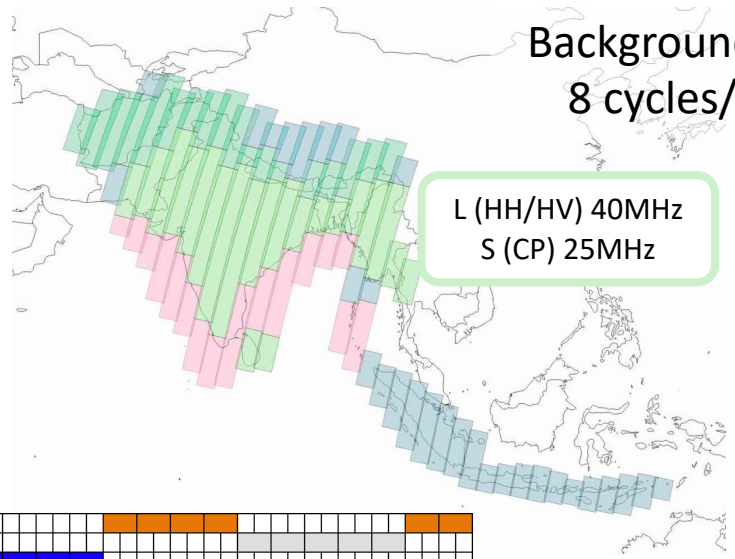
# India and Environs Observation Plan

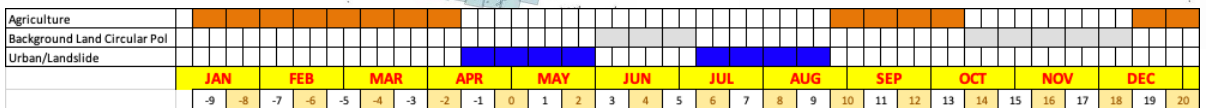



Descending

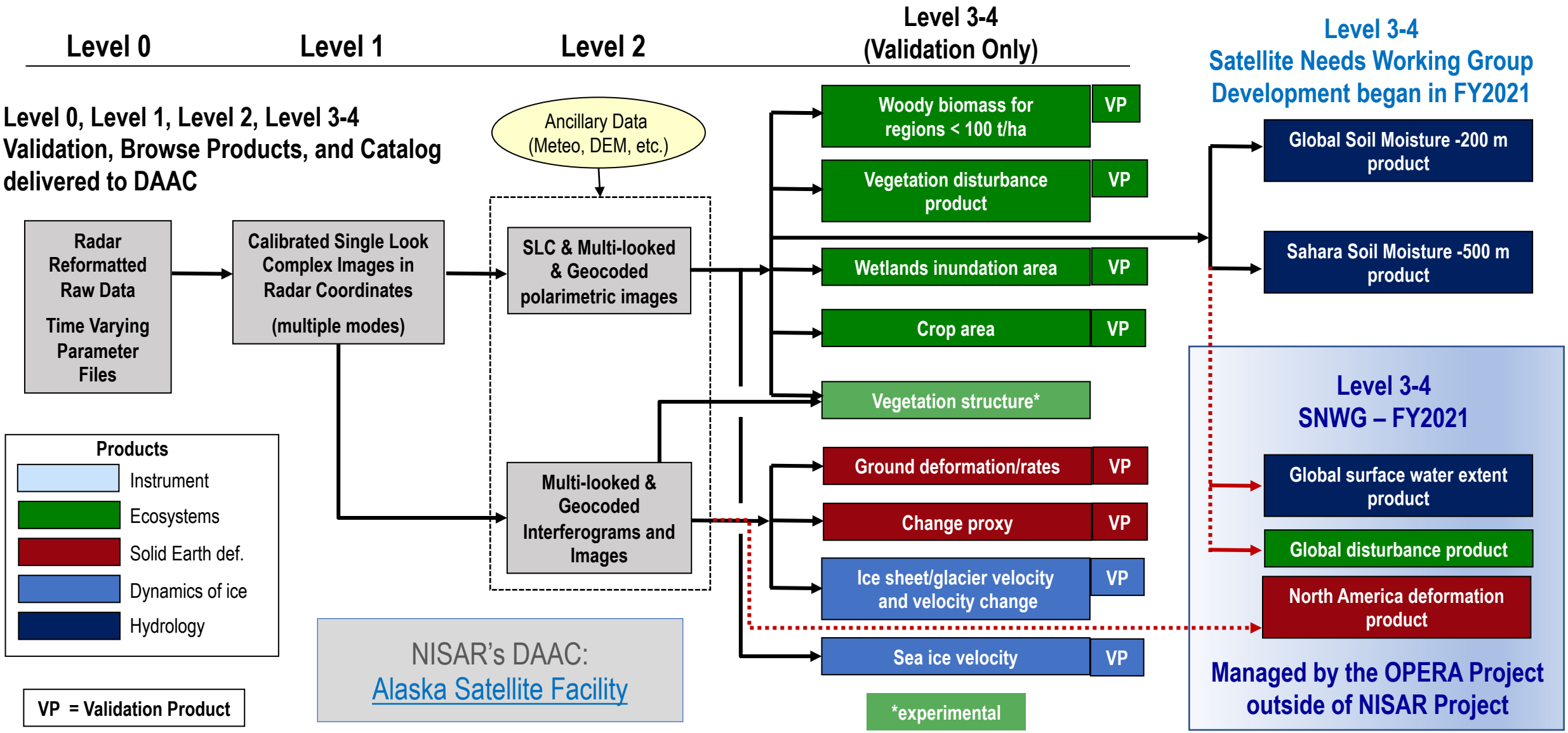


# NISAR Science Data Analysis and Archive Approach



# Open-Source Science for NISAR

- Open data – per NASA data policy – at the Alaska Satellite Facility DAAC
  - Pre-launch L-band sample products: https://uavsar.jpl.nasa.gov/science/documents/nisar-sample-products.html
    - NISAR resolution, noise properties, formats, and mode characteristics
  - Pre-launch L-/S-Band products: 150+ scenes from ISRO ASAR instrument flown in US
    - Native resolution and noise properties, quad-pol, NISAR format
  - Post-launch Science products
  - *NISAR will be two times larger than the current EODIS Archive.*
- Open Source Software – SDS and data processing code available for download
  - InSAR Scientific Computing Environment, Enhanced Edition (ISCE3): https://github.com/isce-framework/isce3
- Open Source Science algorithms for science products
  - Jupyter notebooks available for download: https://gitlab.com/nisar-science-algorithms
- Open Source Training Opportunities
  - Jupyter notebooks in cloud training environments at Alaska Satellite Facility OpenScienceLab
  - ARSET and other courses: https://nisar.jpl.nasa.gov/resources/sar-education-resources/
- Cloud computing resources for NASA subscribers