Paul Siqueira
Lead NISAR Ecosystems
Science Team
Quick Overview
NISAR Mission at a glance

- Four Level-1 Disciplines
  - Ecosystems/Hydrology, Ice Sheets, Solid Earth Dynamics, Applications

- L- & S-band 12-day orbital repeat, left-looking only mission (observations are during ascending and descending passes, so effectively two observations every 12 days)

- 240 km swath using SweepSAR

- Dominant observing mode is L-band dual-pol, 10 m resolution (40 MHz US; 20 MHz elsewhere). S-band collected outside of India at Cal/Val sites.

- Launch in 2022 (May)

- 4.5 TB/day data downlink

- NISAR is a requirements driven mission.

- NISAR is not currently delivering any L3 science products (only L2 with L3 algorithms & requirements verified over cal/val sites)

- Example of a NISAR requirement (biomass):
  
  NISAR will estimate global above ground biomass up to 100 t/ha at a 1 ha resolution, with an accuracy of 20 t/ha.

- NISAR repeat-observations used to reduce soil moisture and speckle effects in the data.
Mode-Specific Science Targets in Observation Plan

Planned Acquisitions

- Background Land
- Land Ice
- Sea Ice
- Urban (small targets)
- US Agriculture
- Himalayas
- India Agriculture
- India Coastal Ocean
- Sea Ice Type

Background Land satisfies most Solid Earth and Ecosystems objectives

US-Quad-pol collection is likely to occur for the states of: Illinois, Michigan, Ohio & parts of Alaska
**NISAR Concept Science Observation Overview**

<table>
<thead>
<tr>
<th>NISAR Characteristic:</th>
<th>Would Enable:</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-band (24 cm wavelength)</td>
<td>Low temporal decorrelation and foliage penetration</td>
</tr>
<tr>
<td>S-band (12 cm wavelength)</td>
<td>Sensitivity to light vegetation</td>
</tr>
<tr>
<td>SweepSAR technique with Imaging Swath &gt; 240 km</td>
<td>Global data collection</td>
</tr>
<tr>
<td>Polarimetry (Single/Dual/Quad)</td>
<td>Surface characterization and biomass estimation</td>
</tr>
<tr>
<td>12-day exact repeat</td>
<td>Rapid Sampling</td>
</tr>
<tr>
<td>3 – 10 meters mode-dependent SAR resolution</td>
<td>Small-scale observations</td>
</tr>
<tr>
<td>3 years science operations (5 years consumables)</td>
<td>Time-series analysis</td>
</tr>
<tr>
<td>Pointing control &lt; 273 arcseconds</td>
<td>Deformation interferometry</td>
</tr>
<tr>
<td>Orbit control &lt; 500 meters</td>
<td>Deformation interferometry</td>
</tr>
<tr>
<td>&gt; 30% observation duty cycle</td>
<td>Complete land/ice coverage</td>
</tr>
<tr>
<td>Left/Right pointing capability</td>
<td>Polar coverage, north and south</td>
</tr>
</tbody>
</table>

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

**Observation Geometry**

- **Earth surface**
- **747 km**
- **33°**
- **47°**
- **6 AM / 6 PM**

**Siqueira – NISAR Ecosystems Lead**
Observation strategy employs a small subset of possible modes

<table>
<thead>
<tr>
<th>Observation Strategy</th>
<th>L-band</th>
<th>S-band</th>
<th>Culling Approach</th>
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<tr>
<td><strong>Science Target</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Background Land</td>
<td>DP HH/HV</td>
<td>12 m x 8 m</td>
<td>cull by lat</td>
</tr>
<tr>
<td>Land Ice</td>
<td>SP HH</td>
<td>3 m x 8 m</td>
<td>cull by lat</td>
</tr>
<tr>
<td>Sea Ice Dynamics</td>
<td>SP VV</td>
<td>48 m x 8 m</td>
<td>s = 1 p</td>
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<tr>
<td>Urban Areas</td>
<td></td>
<td>6 m x 8 m</td>
<td>s = 1 p</td>
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<tr>
<td>US Agriculture</td>
<td>QP HH/HV VV/VH</td>
<td>s = 1 p</td>
<td></td>
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<tr>
<td>Himalayas</td>
<td>CP RH/RV</td>
<td>s = 1 p</td>
<td></td>
</tr>
<tr>
<td>India Agriculture</td>
<td></td>
<td>s = 1 p</td>
<td></td>
</tr>
<tr>
<td>India Coastal Ocean</td>
<td>DP HH/HV or VV/VH</td>
<td>s = 1 p</td>
<td></td>
</tr>
<tr>
<td>Sea Ice Types</td>
<td>DP VV/VH</td>
<td>s = 3 p</td>
<td></td>
</tr>
</tbody>
</table>
• New Team!

Paul Siqueira, Bruce Chapman, Josef Kellndorfer, Sassan Saatchi, Ralph Dubayah, Nathan Torbick, Narendra Das, Seungbum (Sab) Kim, Rajat Bindlish, Rick Forster, Rowena Lohman, Kyle McDonald

• Currently Ecosystems & Hydrology/Soil Moisture are combined because of the many common themes and interests between the disciplines.

• NISAR Science Team meetings three times yearly
Individual Activity & Timeline

NISAR Project Life Cycle (NASA)

- **Phase A**
  - KDP-A: Mar. 19, 2014
- **Phase B**
  - KDP-B: Feb. 12, 2015
  - SRR/MDR: Dec. 9–11, 2014
  - First JSG: Jul. 2015
  - PDR: June. 2016
- **Phase C**
  - CDR: Oct. 2018
- **Phase D**
  - KDP-D: Dec. 2019
  - SIR: Dec. 2019
  - S-SAR Delivery to JPL: Jun. 2019
  - NISAR Instrument (L- and S-SAR) Delivery to ISAC: Feb. 2021

**Launch**
- May 2022

**Today**
- S-SAR Delivery to JPL: Jun. 2019
- NISAR Instrument (L- and S-SAR) Delivery to ISAC: Feb. 2021

UNDER REVISION
NISAR Stowed Configuration

- Star Trackers from ISRO
- Radar Instrument Structure (Metallic structure: In-house, Composite structure: Competitive procurement)
- Radar Antenna Reflector (Competitive procurement)
- Radar Antenna Boom (JPL or US competitive procurement)
- L-band Electronics: JPL
- S-band Electronics: ISRO

Recent concept: details still being worked
L-SAR Integration is Nearly Complete
Boom Segments are Complete and Being Integrated
Reflector is in Final Assembly & Test

NGAS Astro Aerospace Proprietary

Created under NASA/JPL NISAR Subcontract No. 1537496
NASA-ISRO Observatory Work Share

On-Orbit Configuration

- Spacecraft Bus System (ISRO URSC)
  - I3K heritage bus with modifications

- Radar Payload System
  - L-band SAR aka DSI (NASA)
  - S-band SAR (ISRO SAC)

- Engineering Payload System (NASA)
  - Payload Communication Subsystem (PCS)
    - Ka-band high rate transmitter
  - GPS Payload (GPSP)
  - Solid State Recorder (SSR)
  - Payload Data Subsystem (PDS)
  - Power Distribution Unit (PDU)
  - Pyro Firing Assembly (PFA)

- Launch Vehicle (ISRO VSSC)
  - Geosynchronous Satellite Launch Vehicle (GSLV) Mark-II (4-meter fairing)

DSI = Dual-band SAR Instrument

URSC: U. R. Rao Satellite Centre
SAC: Space Applications Centre
VSSC: Vikram Sarabhai Space Centre
SAR coverage (JERS-1)

- Active sensor and weather tolerance improves dependability
- For JERS-1, Every 44 days, a partial view of the Earth’s surface could be made

NISAR will collect similar data, regularly, every 12 days at a 10m SLC resolution

HH and HV polarizations

240 km swath

The radiometric quality is not great for this image, but it shows very well the different orbits of JERS-1 and the methodical way that it was able to collect data with a 70 km swath. NISAR will offer a similar capability, with global-land coverage, two times every 12 days.
Track/Frame data collection

- Data are planned to be collected in track/frame coordinate system
- 173 unique tracks that comprehensively span the equator
- Within a single track/frame, data collection mode will be uniform, at the lowest bandwidth
- Higher bandwidth segments delivered separately
• 41 Tbits / day total L+S band science data downlink
Nominal Ecosystem Cal/Val sites

NISAR Ecosystems/Hydrology Status & Upcoming Events

- **Status**
  - ATBD and Cal/Val plans completed but now being re-reviewed
  - ATBD’s being encoded into Jupyter notebooks
  - Workshops in all disciplines completed in recent years

- **UAVSAR AM/PM Campaign** is complete

- **ASAR Campaign**
  - L + S band airborne SAR provided by ISRO
  - Data collections in the US

- **NISAR Land Data Products**
  - Soil Moisture global data product
  - SLC data distributed by ASF. Available within 30 days of collection, or (likely) much sooner
  - 20m HDF5 products of HH, HV power in UTM/MGRS
  - All ground-projected data to be radiometrically terrain corrected (RTC)
• Flight coverage

• Mimic the NISAR diurnal observing pattern in a hydrologically dynamic environment

• 14 sites that cover Biomass, Disturbance, Wetlands, Agriculture, Soil Moisture diversity, Oil spill, Subsidence and other disciplines

• fData collected between June and October (12 nominal repeat)
<table>
<thead>
<tr>
<th>Site Name</th>
<th>AM</th>
<th>PM</th>
<th>Total</th>
<th>Success rate AM</th>
<th>Success rate PM</th>
<th>Success rate overall</th>
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<td>6</td>
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<td>Lenoir Landing (LENO)</td>
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<td>7</td>
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<td>Talledega (TALL)</td>
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<td>ORNL</td>
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<td>75%</td>
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<tr>
<td>AR2 and FM3</td>
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<td>67%</td>
<td>75%</td>
<td>71%</td>
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<td>6</td>
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<td>78%</td>
<td>75%</td>
<td>76%</td>
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<tr>
<td>Yucatan Lake</td>
<td>5</td>
<td>7</td>
<td>12</td>
<td>56%</td>
<td>88%</td>
<td>71%</td>
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<tr>
<td>FM1 and Subsidence</td>
<td>7</td>
<td>7</td>
<td>14</td>
<td>78%</td>
<td>88%</td>
<td>82%</td>
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<tr>
<td>Subsidence TX</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>63%</td>
<td>63%</td>
<td>63%</td>
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<tr>
<td>AR1</td>
<td>7</td>
<td>4</td>
<td>11</td>
<td>78%</td>
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<td>65%</td>
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<tr>
<td>Tifton</td>
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<td>4</td>
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<tr>
<td>Oil Spill</td>
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<tr>
<td>White Lake</td>
<td>8</td>
<td>8</td>
<td>16</td>
<td>89%</td>
<td>89%</td>
<td>89%</td>
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<tr>
<td><strong>Totals</strong></td>
<td>75</td>
<td>73</td>
<td>148</td>
<td>76%</td>
<td>76%</td>
<td>77%</td>
</tr>
</tbody>
</table>
NASA

- NASA provides a C-20A (Gulfstream-III) aircraft, a radar instrument pod, and the navigation package.

- NASA collects L+S band SAR data from ISRO’s ASAR instrument. When possible, NASA’s UAVSAR system will co-collect imagery over a common scientific targets.

- Collaborate with ISRO investigators on the scientific analysis of the ISRO L- and S-band ASAR data.

ISRO

- ISRO provides L+S band Airborne Synthetic Aperture Radar (ASAR), payload structure, data processing equipment.

- Process ASAR instrument data acquired during the campaigns to generate scientific data products (Level 0, 1 & 2).

- Collaborate with NASA investigators on the scientific analysis of the ISRO L- and S-band ASAR data.
• Flight campaign to occur in three phases
• First phases completed in December 2019
• Data being evaluated and delivered now

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<th>SN</th>
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<tr>
<td>2</td>
<td>5-Dec-2019</td>
<td>14/16</td>
<td>CA</td>
</tr>
<tr>
<td>3</td>
<td>9-Dec-2019</td>
<td>2/2</td>
<td>Palmdale to Fairbanks</td>
</tr>
<tr>
<td>4</td>
<td>10-Dec-2019</td>
<td>10/12</td>
<td>Alaska</td>
</tr>
<tr>
<td>5</td>
<td>11-Dec-2019</td>
<td>12/12</td>
<td>Alaska</td>
</tr>
<tr>
<td>6</td>
<td>12-Dec-2019</td>
<td>14/13</td>
<td>Alaska</td>
</tr>
<tr>
<td>7</td>
<td>14-Dec-2019</td>
<td>7/7</td>
<td>Alaska</td>
</tr>
<tr>
<td>8</td>
<td>15-Dec-2019</td>
<td>6/6</td>
<td>Nr Seattle</td>
</tr>
<tr>
<td>9</td>
<td>16-Dec-2019</td>
<td>13/13</td>
<td>Portland to Palmdale</td>
</tr>
</tbody>
</table>

2TB+2TB = 4TB Data collected in L+S Band
December 14, 2019 -- Alaska

S-band

L-band

Polarization - VV
Learn More about NISAR
https://nisar.jpl.nasa.gov

Applications

Ecosystem

White Papers
Fire Management (PDF, 1.78 MB)
Food Security (PDF, 1.01 MB)
Forest Resources (PDF, 2.02 MB)
Timber and Forest Disturbance (PDF, 2.7 MB)
Flood Forecasting (PDF, 3.52 MB)

Workshop reports
Vegetation Biomass Workshop Report (June 2016)

Maritime Hazards and Coastal Waters

White Papers
Coastal Land Loss (PDF, 2.56 MB)
Oil Spills (PDF, 3.48 MB)
Ice Sheets, Glaciers, and Oceans (PDF, 1.19 MB)
Marine Hazards (PDF, 1.44 MB)
Sea Ice (PDF, 2.21 MB)

Workshop reports
Sea Ice and Ocean Applications Workshop Report (June 2017)
• NISAR has a 264 page science handbook!
  • Available now as a pdf (nisar.jpl.nasa.gov/getengaged/resources/)
  • Available in hard copy at a NASA center near you!
The SAR Handbook
Forest Monitoring & Biomass Estimation

- 7 Technical chapters with examples
  - Basic principles and data access
  - Forest Disturbance Monitoring
  - Forest Stand Height Estimation
  - Biomass Mapping
  - Remote Sensing of Mangroves
  - Sampling Designs for SAR-driven surveys

- Peer reviewed
- Deployed at SERVIR centers distributed worldwide
Top countries by Handbook materials accessed:

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Access</th>
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<td>China</td>
<td>8,543</td>
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<td>4</td>
<td>Spain</td>
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Top countries currently covered by SERVIR:

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<th>SERVIR Region</th>
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<td>Pakistan</td>
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<tr>
<td>Ecuador</td>
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Between April 10 – May 5, 2019

• The full Handbook has been accessed more than 103,000 times
• Full Handbook and additional materials have been accessed more than 136,000 times
• 149 countries have accessed SAR Handbook and complementary materials