The NISAR Mission

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Quick Overview
JAXA KC25
NASA-ISRO SAR : NISAR

Partnership between NASA and ISRO

L-band and S-band SAR

Polarimetric (standard mode: HH and HV)

Bandwidth: from 5 Mhz to 80 MHz

Split spectrum to correct for ionosphere

All data will be made available free and open

Wide swath SweepSAR mode, **global coverage at 12 day repeat**

Data acquired **ascending and descending**

>26 Tbits/day downlink

Launch December 2011/January 2022

Visit nisar.jpl.nasa.gov for more information
NISAR Mission at a glance

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

• Left-looking only mission

• 240 km swath using SweepSAR

• Dominant observing mode is L-band dual-pol, 10 m resolution

• 26Tbits/day data downlink, enables up to 100TB/day science data volume

• NISAR is a requirements driven mission.

• NISAR repeat-observations used to reduce soil moisture and speckle effects in the data.
### Level 1 Science Requirements

Need to be met to

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Details</th>
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<tbody>
<tr>
<td>Measure time-varying displacements over Earth’s land and ice-covered surfaces with an average sampling capability of 6 days at 100-m scale; displacement error shall be less than 20 mm over any 12-day interval.</td>
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<tr>
<td>Measure sea ice velocities on a 5 km grid every 3 days for both Arctic and Antarctic sea-ice cover; velocity error shall be less than 100 m/day.</td>
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<td>Measure time-varying displacements over Earth’s land and ice-covered surfaces with an average sampling capability of 6 days at 100-m scale; displacement error shall be less than 20 mm over any 12-day interval.</td>
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<tr>
<td>Map aboveground woody vegetation biomass and its disturbance and recovery globally at the hectare scale with an accuracy of 20 Mg/ha for areas of biomass less than 100 Mg/ha.</td>
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<td>Seasonally map global cropland and inundated areas with a classification accuracy of 80% at hectare scale.</td>
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<td>In support of response to major natural or anthropogenic disasters, the mission system shall be capable of scheduling a new acquisition within 24 (TBR) hours of the event and delivering data within 5 (TBR) hours of being collected.</td>
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## Level 2 Science Requirements

<table>
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<tr>
<th>Requirement</th>
<th>Baseline Mission</th>
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<tbody>
<tr>
<td><strong>Requirement</strong></td>
<td>2-D Solid Earth Displacement</td>
</tr>
<tr>
<td>Resolution</td>
<td>100m</td>
</tr>
<tr>
<td>Accuracy</td>
<td>3.5 (1+SQRT(L)) mm or better, 0.1 km &lt; L &lt; 50 km, over 70% of areas of interest</td>
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<tr>
<td>Sampling interval</td>
<td>12 days or better, over 80% of all intervals, &lt; 60 day gap over mission</td>
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<tr>
<td>Coverage</td>
<td>Land areas predicted to move faster than 1 mm/yr, volcanoes, reservoirs, glacial rebound, landslides</td>
</tr>
<tr>
<td>Duration</td>
<td>36 months</td>
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</table>
NISAR Systematic Observations Designed to Capture Earth’s Dynamics

No target conflicts: overlapping targets uses union of all modes specified

Colors indicate different radar modes

Note: conceptual plan – does not reflect current detailed plan

12-day regular sampling on ascending and descending to the extent possible
Radar Payload Concept

- World’s first dual frequency (L- and S-band) space-borne SweepSAR
- Repeat pass interferometry
- Fully polarimetric SAR capability
- Array-fed reflector (boresight at ~37 degrees from nadir, transmitting a fan beam, and receiving with multiple pencil beams)
  - Shared reflector for both L- and S-bands
  - Separate L- and S-band feeds
  - Incidence angles: 30 – 42 degrees
- Observatory pointing control +/- 273 arcsec
- Active front-end electronics, high efficiency T/R module, high rate analog-to-digital converter (ADC), and on-board processing

SweepSAR algorithm was demonstrated using an airborne Ka-band SAR
Mode-Specific Science Targets in Observation Plan

Each colored region represents a single radar mode chosen to satisfy multiple science objectives over that area. Avoids mode contention that would interrupt time series.

Background Land satisfies most Solid Earth and Ecosystems objectives.

Planned Acquisitions:
- Background Land
- Land Ice
- Sea Ice
- Urban (small targets)
- US Agriculture
- Himalayas
- India Agriculture
- India Coastal Ocean
- Sea Ice Type
NISAR Project Life Cycle (NASA)

- **Phase A**
  - KDP-A: Mar. 19, 2014
  - SRR/MDR: Dec. 9–11, 2014

- **Phase B**
  - KDP-B: Feb. 12, 2015
  - First JSG: Jul. 2015
  - PDR: June. 2016

- **Phase C**
  - CDR: Oct. 2018
  - SIR: Dec. 2019

- **Phase D**
  - KDP-D: Dec. 2019
  - KDP-E: Dec. 2021
  - S-SAR Delivery to JPL: Jun. 2019
  - NISAR Instrument (L- and S-SAR) Delivery to ISAC: Feb. 2021

- **Launch**
  - 2021

**Today**
NISAR Development: Ecosystems

- Biomass
- Disturbance
- Inundation
- Agriculture

Dense-time series of L-band data (dual-pol)
The global distribution of regions dominated by woody biomass < 100 Mg/ha

- Green: Regions with AGB < 100 Mg/ha, 50% of area
- Red: Regions with AGB > 100 Mg/ha, 50% of area
- Yellow: Regions with AGB < 20 Mg/ha, 50% of area
- Open Water
- Other: Regions with no woody vegetation, 50% of area

2018 NISAR Overview
Disturbance Monitoring with Time Series

L-Band HH Backscatter

Cerrado Area, Brazil
ALOS PALSAR DATA from 2006 to 2011

Time Steps
0 2006-12-04
1 2007-01-19
2 2007-03-06
3 2007-07-22
4 2007-10-22
5 2008-01-22
6 2008-03-08
7 2008-04-23
8 2008-06-08
9 2008-07-24
10 2008-09-08
11 2008-10-24
12 2009-01-24
13 2009-03-11
14 2009-07-27
15 2009-09-11
16 2009-10-27
17 2010-03-14
18 2010-04-29
19 2010-06-14
20 2010-07-30
21 2010-09-14
22 2010-12-15
23 2011-01-30
24 2011-03-17

Abrupt drop in Backscatter
Gradual drop in Backscatter
Periodic patterns from seasonal flooding
Vegetation Inundation Dynamics

L-band SAR observations are established as the most reliable tool for mapping vegetation inundation.

- Existing L-band SAR satellites have limited coverage and observations to accurately capture the spatial extent and temporal variations of inundation over wetlands.

- NISAR plans to acquire minimum of dual-pol data globally over all wetlands twice per 12 day orbit cycle will contribute significantly to understanding wetland hydrology and the impacts of climate variations.

JERS-1 L-band SAR (HH only) data showing inundation dynamics for 1 year (Jau River, Brazil)

Crops cover 11% of the Earth’s land surfaces and are expanding regionally in response to climate change and food security.

Identification of crop area is a precursor to crop classification and allows basic monitoring of agricultural resources and outputs.

Changes in observed radar backscatter from NISAR time series data throughout the growing season is an indicator of active landcover management & crop area.
Take Home Messages

• NISAR will collect 30-60 dual-pol images per year over most land surfaces

• Ecosystems are driven by the hydrologic cycle.
  • In terms of biomass, disturbance and agricultural area, this is the dominant source of error

• NISAR Ecosystems benefits greatly by field campaigns and cal/val sites that monitor soil moisture, vegetation condition, and biomass

• NISAR is set to launch in late 2021/early 2022. Data to be distributed freely

• Currently developing plans for
  • Cal/Val
    • Algorithm Theoretical Basis Documents (ATBDs)

• NISAR is developing partners for cal/val
NISAR makes news in Nature magazine!
Hot off the press: February 7, 2019

Article is about NISAR being a left-looking only mission

Q: is all publicity, good publicity?
A: article is less critical than its title let’s on.

Antarctica’s vast ice sheet and surrounding sea ice will be monitored by the NISAR satellite.

Arctic scientists iced out by radar mission

US–India satellite will focus on the Antarctic, upsetting some researchers who study northern ice.

BY ALEXANDRA WITZE

18 | NATURE | VOL 566 | 7 FEBRUARY 2019
Science User’s Handbook

• Comprehensive Document completed to describe Mission, Science Objectives, ATBDs, and Cal/Val Plan
