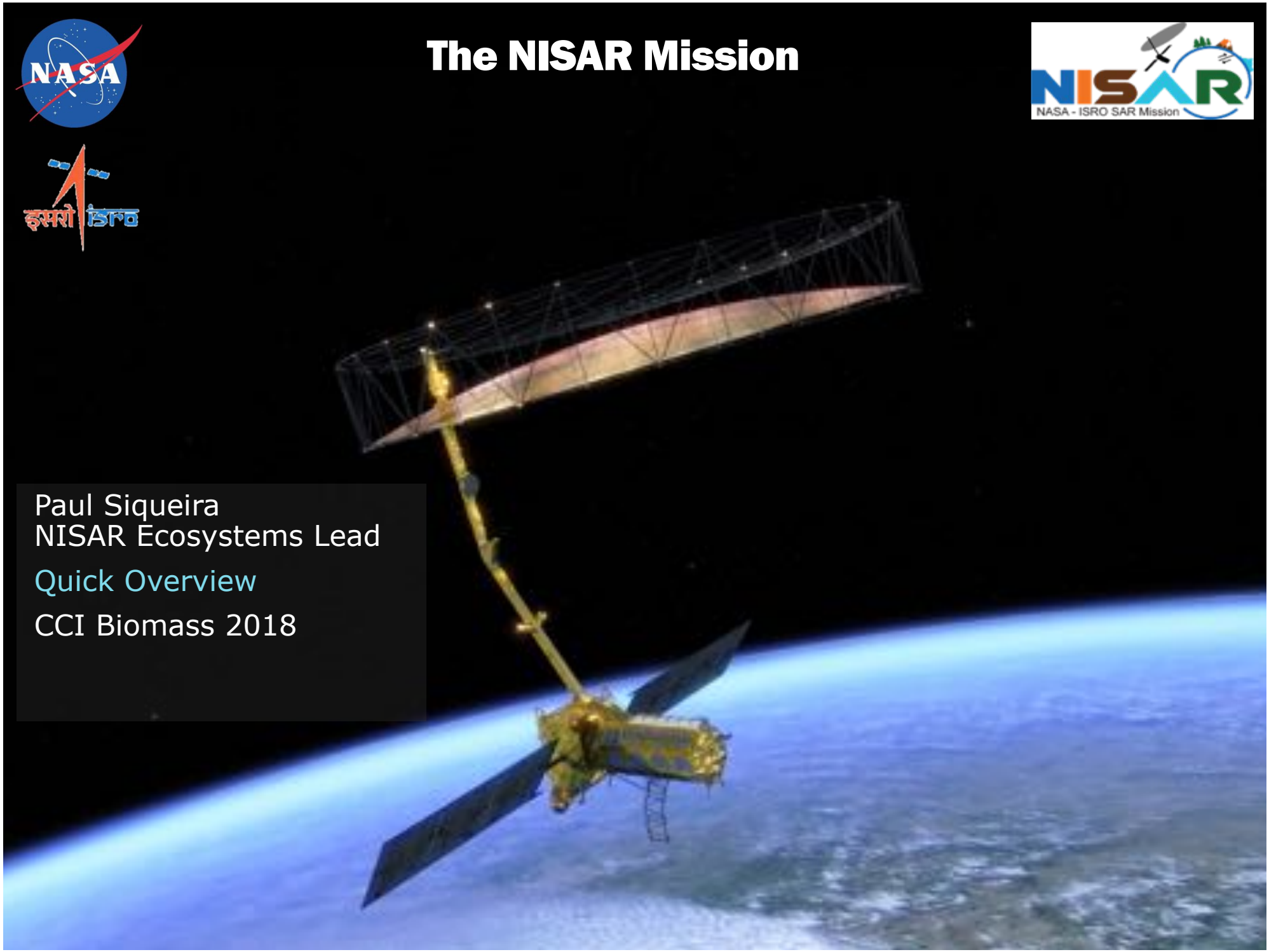
The NISAR Mission



Paul Siqueira
NISAR Ecosystems Lead

Quick Overview

CCI Biomass 2018

NISAR Mission at a glance

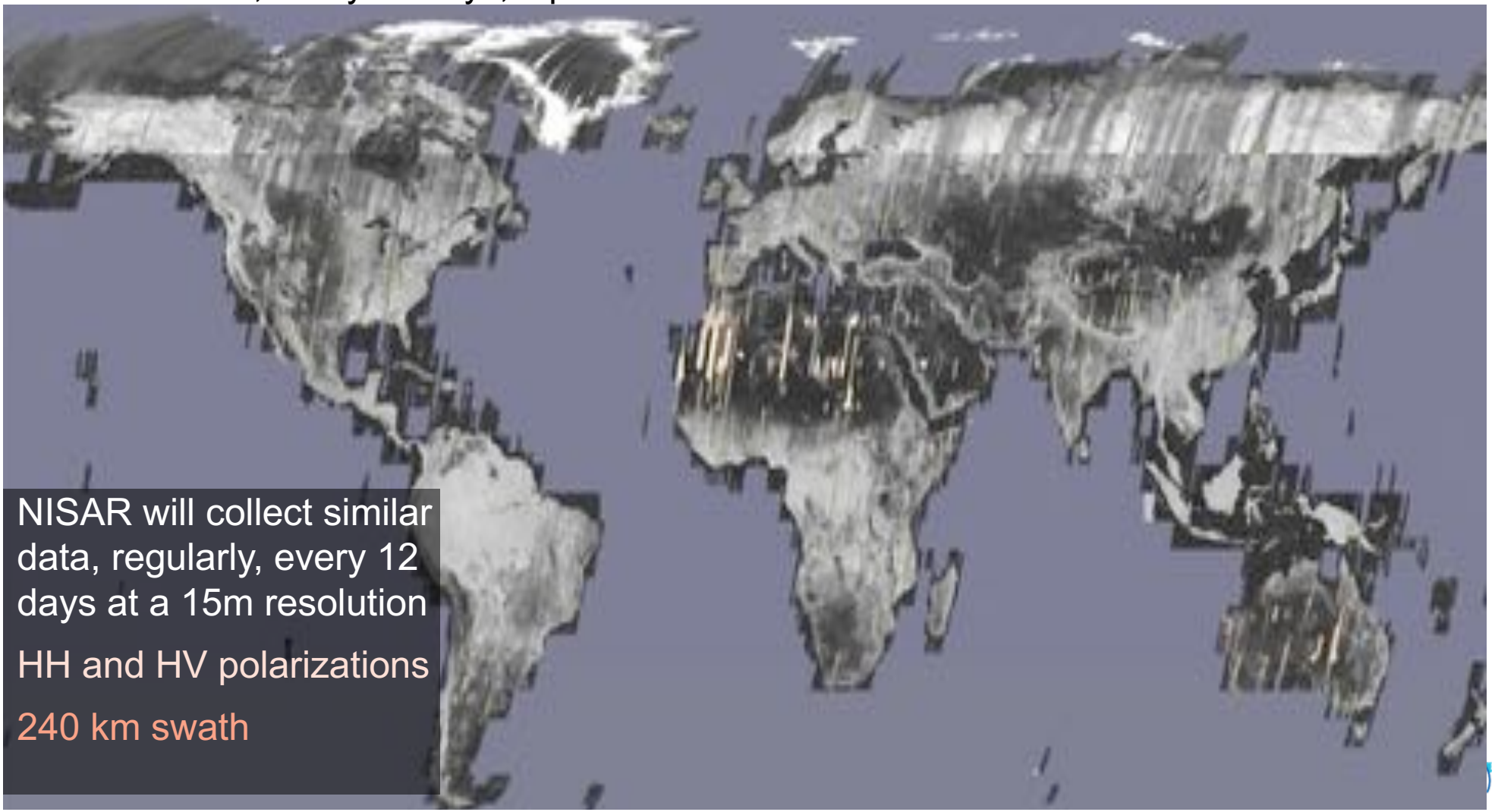
- Four Level-1 Disciplines
  - *Ecosystems, • Ice Sheets, • Solid Earth Dynamics, • Applications*
- L- & S-band 12-day orbital repeat
- 240 km swath using SweepSAR
- Dominant observing mode is L-band dual-pol, 10 m resolution
- Launch in late-2021 (December)
- 3TB/day data downlink

- NISAR is a requirements driven mission.
- NISAR Biomass requirement:

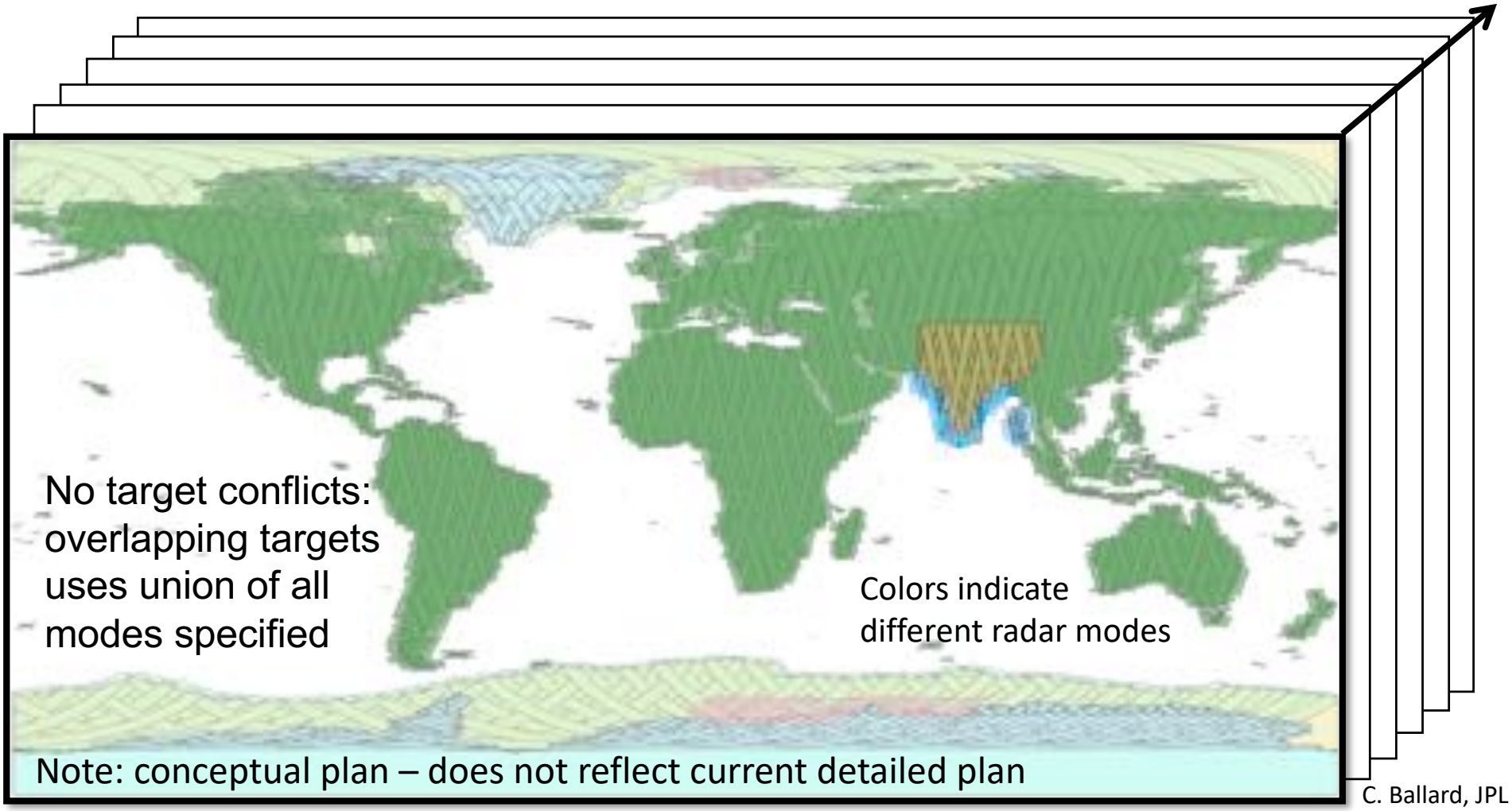
  NISAR will estimate global above ground biomass up to 100 t/ha at a 1 ha resolution, with an accuracy of 20 t/ha.
- NISAR repeat-observations used to reduce soil moisture and speckle effects in the data.

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 Systematic Observations Designed to Capture Earth's Dynamics



C. Ballard, JPL

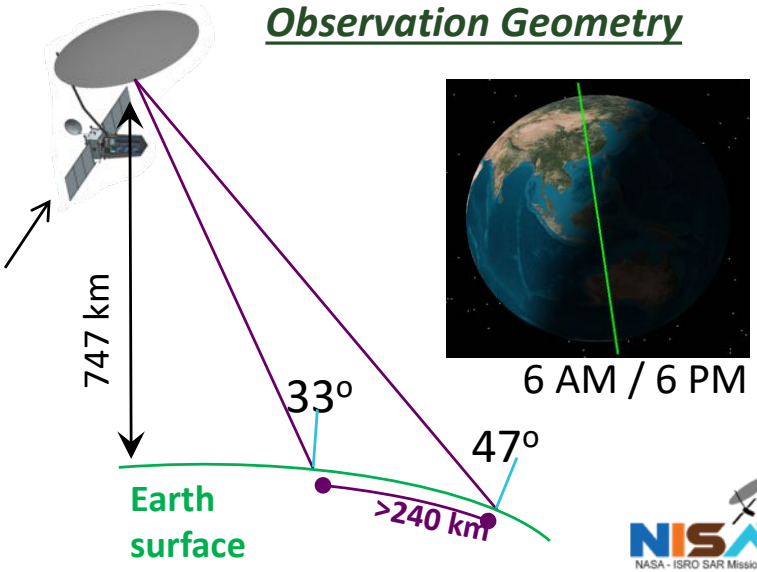
12-day regular sampling on ascending and descending to the extent possible

NISAR Concept Science Observation Overview

NISAR Characteristic:	Would Enable:
L-band (24 cm wavelength)	Low temporal decorrelation and foliage penetration
S-band (12 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 years science operations (5 years consumables)	Time-series analysis
Pointing control < 273 arcseconds	Deformation interferometry
Orbit control < 500 meters	Deformation interferometry
> 30% observation duty cycle	Complete land/ice coverage
Left/Right pointing capability	Polar coverage, north and south

NISAR Would Uniquely Capture the Earth in Motion

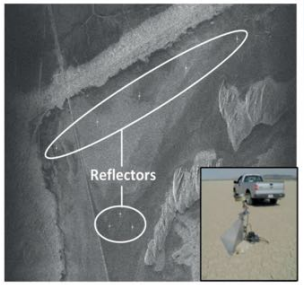
Observation Geometry

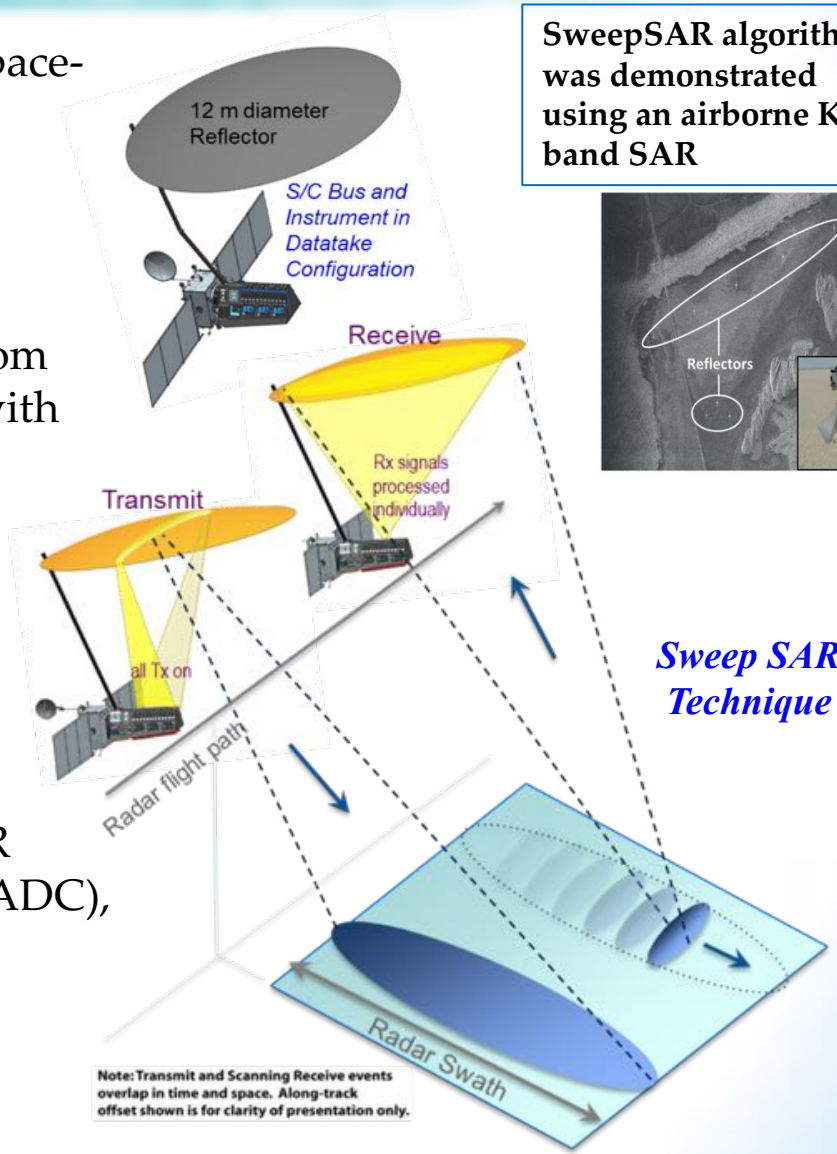


Radar Payload Concept

- 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
  - F/D = 0.75
  - 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

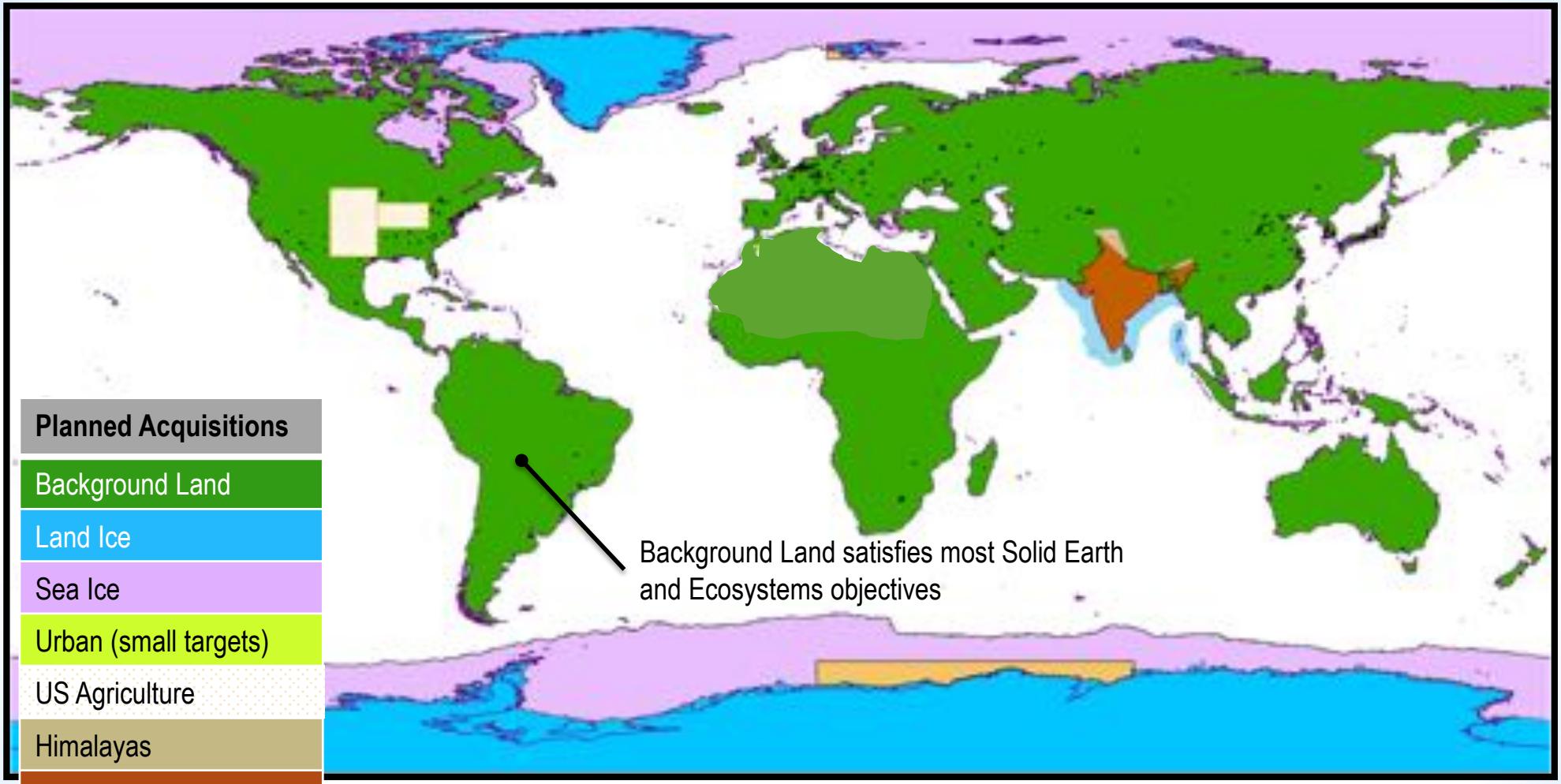
SweepSAR algorithm was demonstrated using an airborne Ka-band SAR





Sweep SAR Technique

Mode-Specific Science Targets in Observation Plan

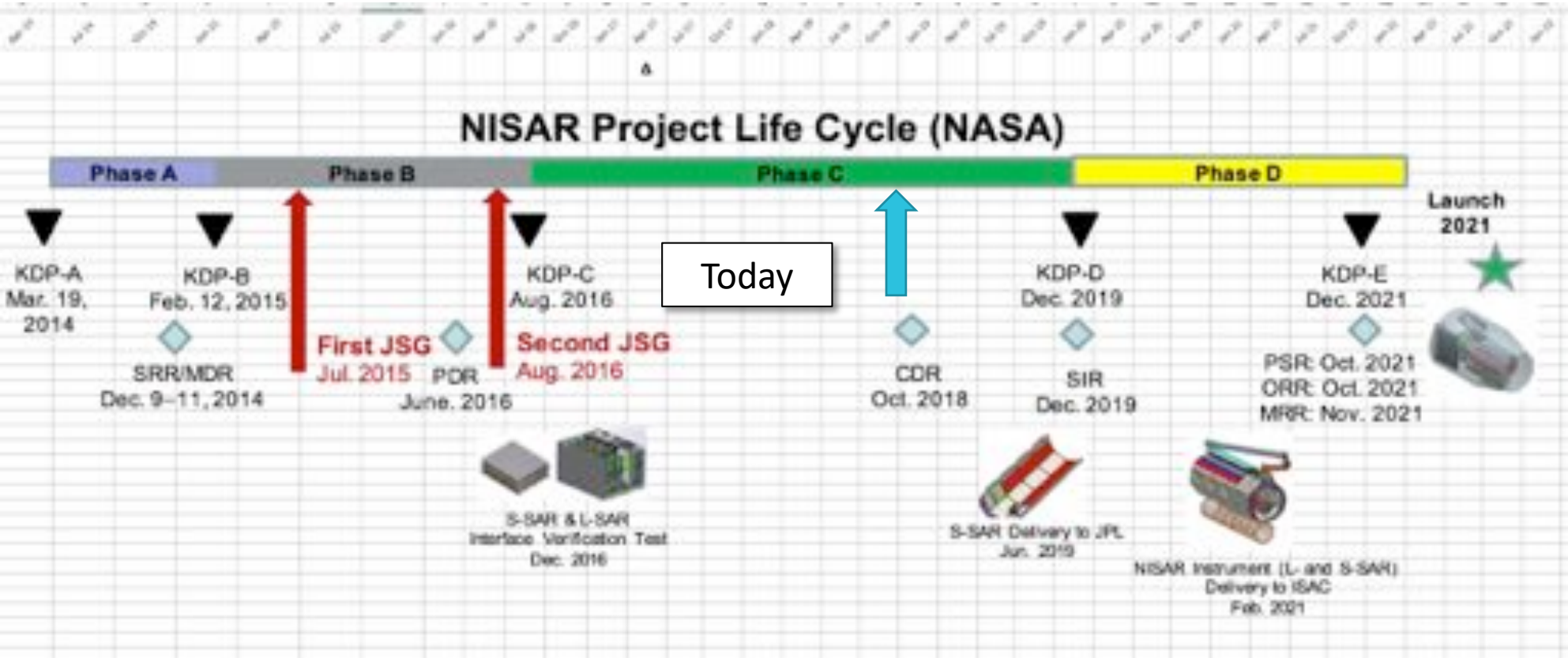


Planned Acquisitions

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

- 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

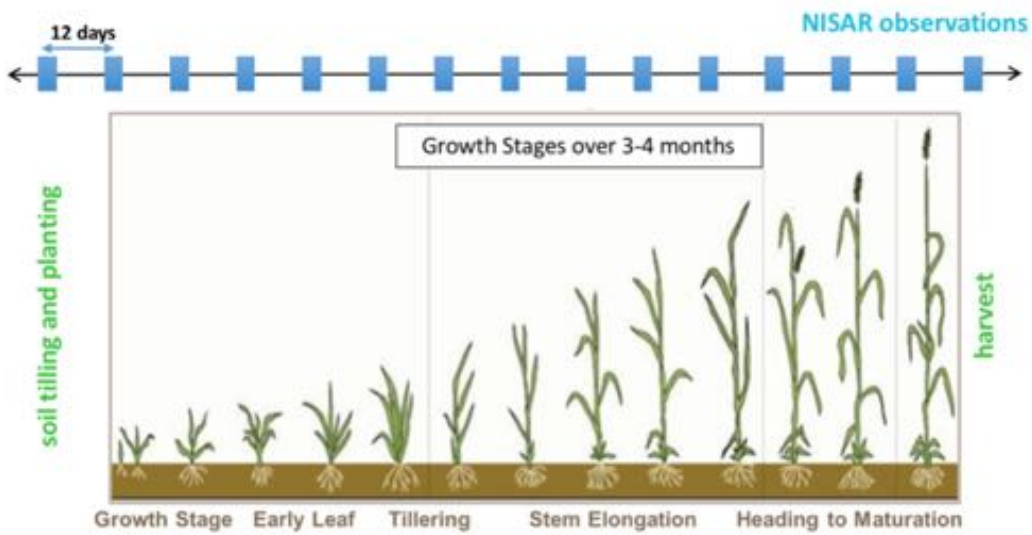
Individual Activity & Timeline

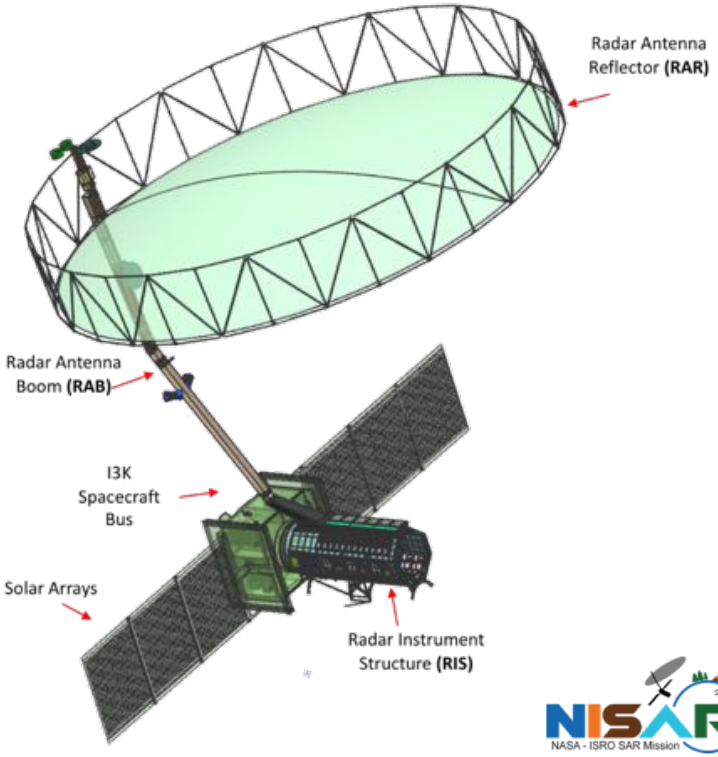


NISAR Development: Ecosystems

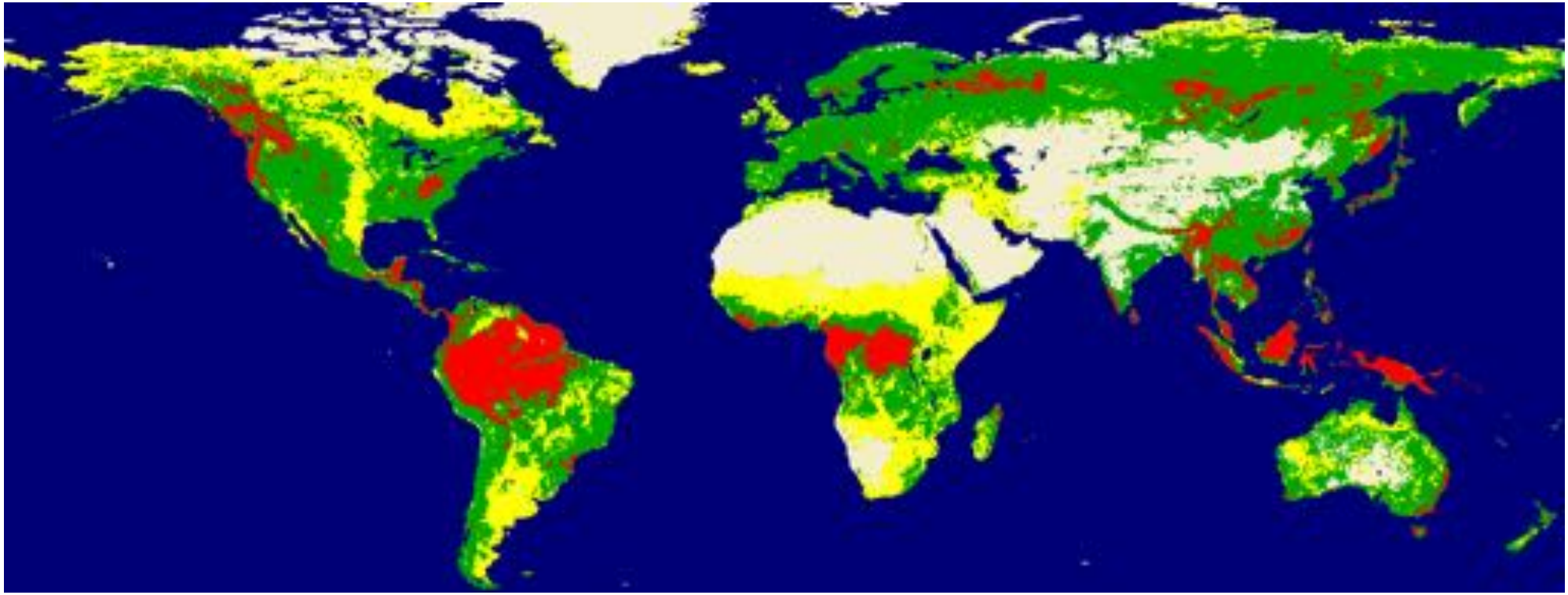
- Biomass
- Disturbance
- Inundation
- Agriculture

Dense-time series of L-band data (dual-pol)





NISAR Biomass areas (< 100 tons/ha)



The global distribution of regions dominated by with woody biomass < 100 Mg/ha

Regions with
AGB < 100 Mg/ha
50% of area

Regions with
AGB > 100 Mg/ha
50% of area

Regions with
AGB < 20 Mg/ha
50% of area

Regions with
No woody
vegetation

Open
Water

Disturbance Monitoring with Time Series

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

L-Band HH Backscatter

Cerrado Area, Brazil
ALOS PALSAR DATA from
2006 to 2011

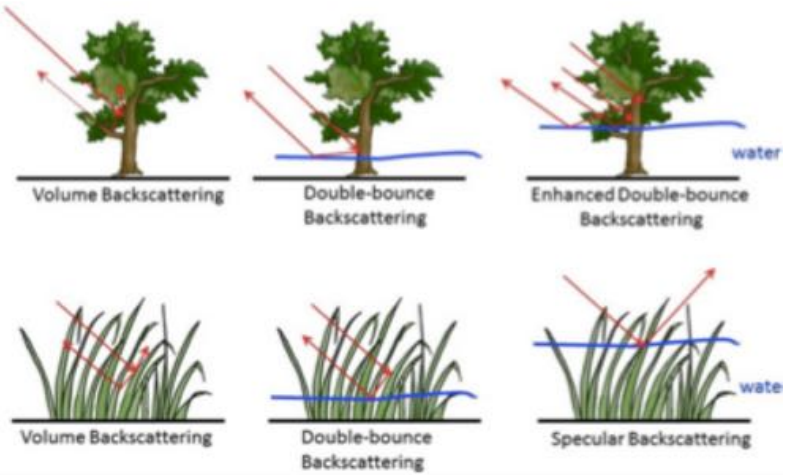
Abrupt drop in Backscatter

Gradual drop in Backscatter

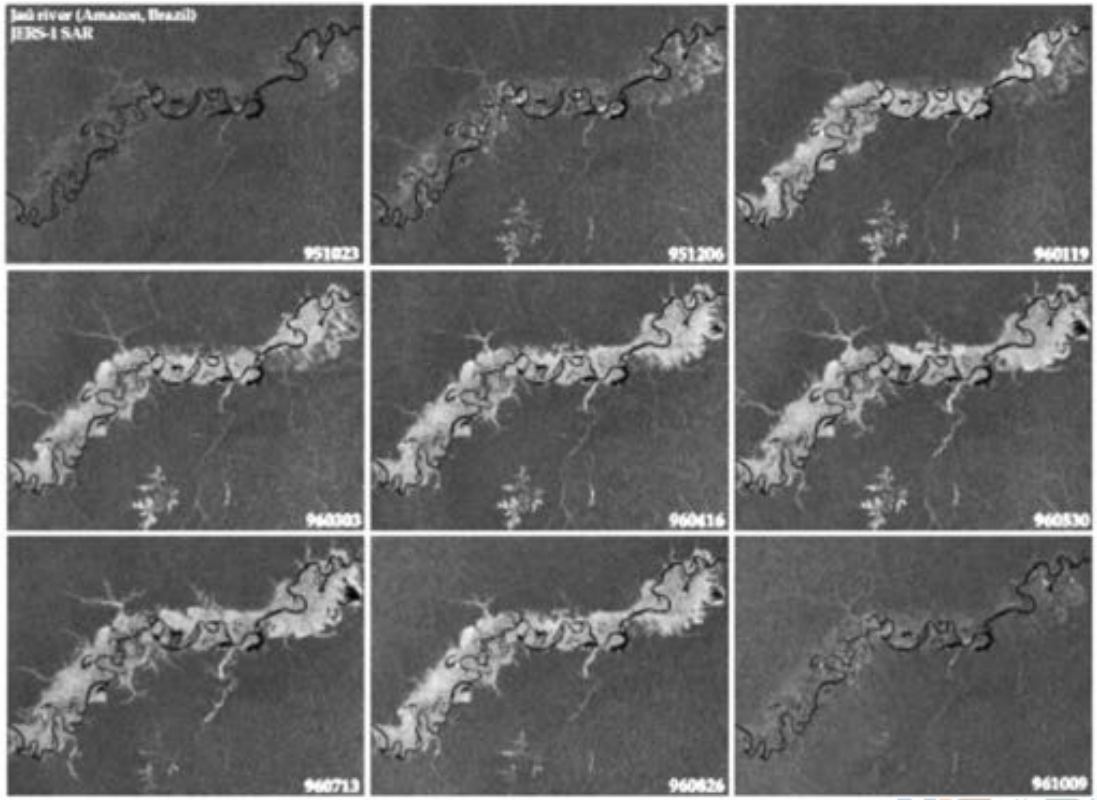
Periodic patterns from seasonal flooding

Vegetation Inundation Dynamics

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



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



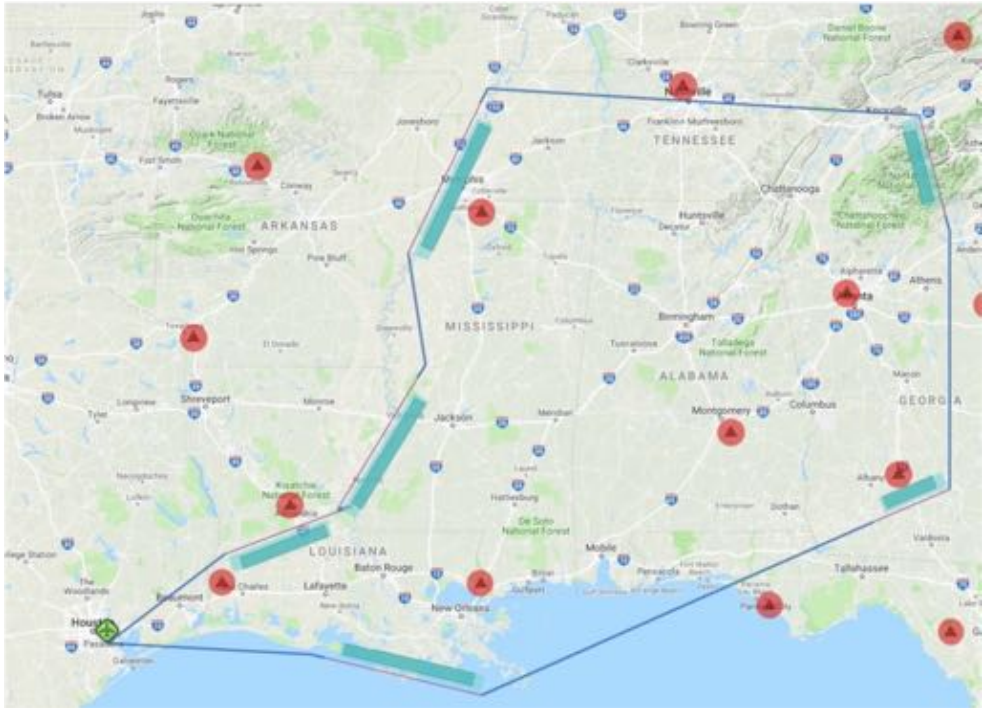
Rosenqvist et al, 1998.

- 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

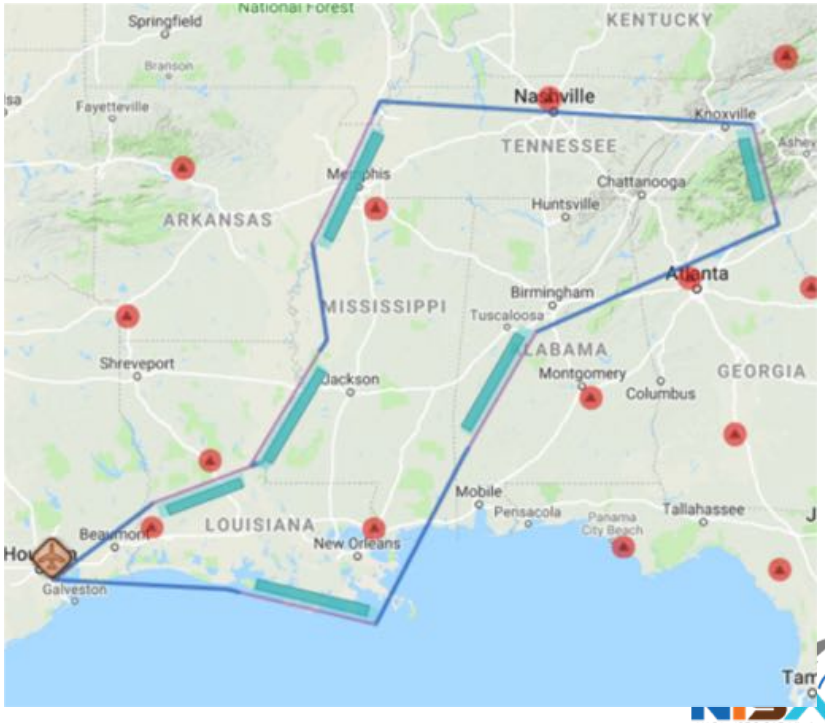
NISAR Ecosystems UAVSAR Campaign

- Ecosystems are driven by a strong hydrologic cycle
- There is a lack of dense time-series L-band data over Ecosystems sites
- In 2019, NISAR is planning on a concerted UAVSAR observing campaign to collect data two times every 12-days over a 6 month period

AM Loop



PM Loop



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 would benefit greatly by field campaigns and cal/val sites that monitor soil moisture, vegetation condition, and biomass
- NISAR is set to launch in 2021. Data to be distributed freely
- Currently developing plans for
  - Cal/Val
  - Algorithm Theoretical Basis Documents (ATBDs)
- NISAR is developing partners for cal/val
  - Contact myself (siqueira@umass.edu), Sassan Saatchi (saatchi@jpl), Bruce Chapman (bruce.d.chapman@jpl) or Natasha Stavros (natasha.stavros@jpl

Other News

Shuttle Mapping Trees with Radar, Pyramids

Shuttle Endeavours To Map U.P. Trees

Radar, Pyramids All Part of U-M Raco Experiment

By Joel Kurth

Scientists hope about one dozen aluminum pyramids among the woods and grazing wild turkeys of western Chippewa County will help forge a unified theory about global warming.

The sheet metal pyramids - trihedrons - are involved in one of several University of Michigan ground experiments held in conjunction with the Saturday, April 9 launch of NASA's space shuttle Endeavour.

Should all go according to plan, the pyramids not only will help the shuttle's radio waves see the Hiawatha National Forest for the trees, but count and identify 2,500-square miles of trees.

The Endeavour is expected to pass over the pyramids 15 times in the next week, said U-M's Craig Dobson.

With each shuttle pass, the pyramids will bounce radio waves back to the spaceship. That may produce history's most accurate information about Eastern Upper Peninsula vegetation, said Dobson, a research scientist at the Center for Space Terahertz Technology.

When this information is merged with new knowledge from 18 other NASA "supersites," a uniform - probably groundbreaking - model will be formed for studying global warming.

Dobson said that scientists, with calculations, can use the data to predict how rising levels of carbon dioxide - global warming - eventually will affect specific locales, such as the Upper Peninsula.

Since most large-scale geological models are wrong, he said, the need

Please turn to page 5

Research scientist Craig Dobson (left) is the mastermind behind the pyramid and radar experiments in Raco. He is coordinating ground activities in conjunction with NASA space shuttle Endeavour's data-collecting mission. Doctorate candidates Paul Siqueira and Jim Stiles (below, left to right) monitor the large pyramids, which act as "mirrors" for the shuttle's bounding radar waves. Stiles is demonstrating the path of the shuttle, which will pass Raco 15 times in its mission.