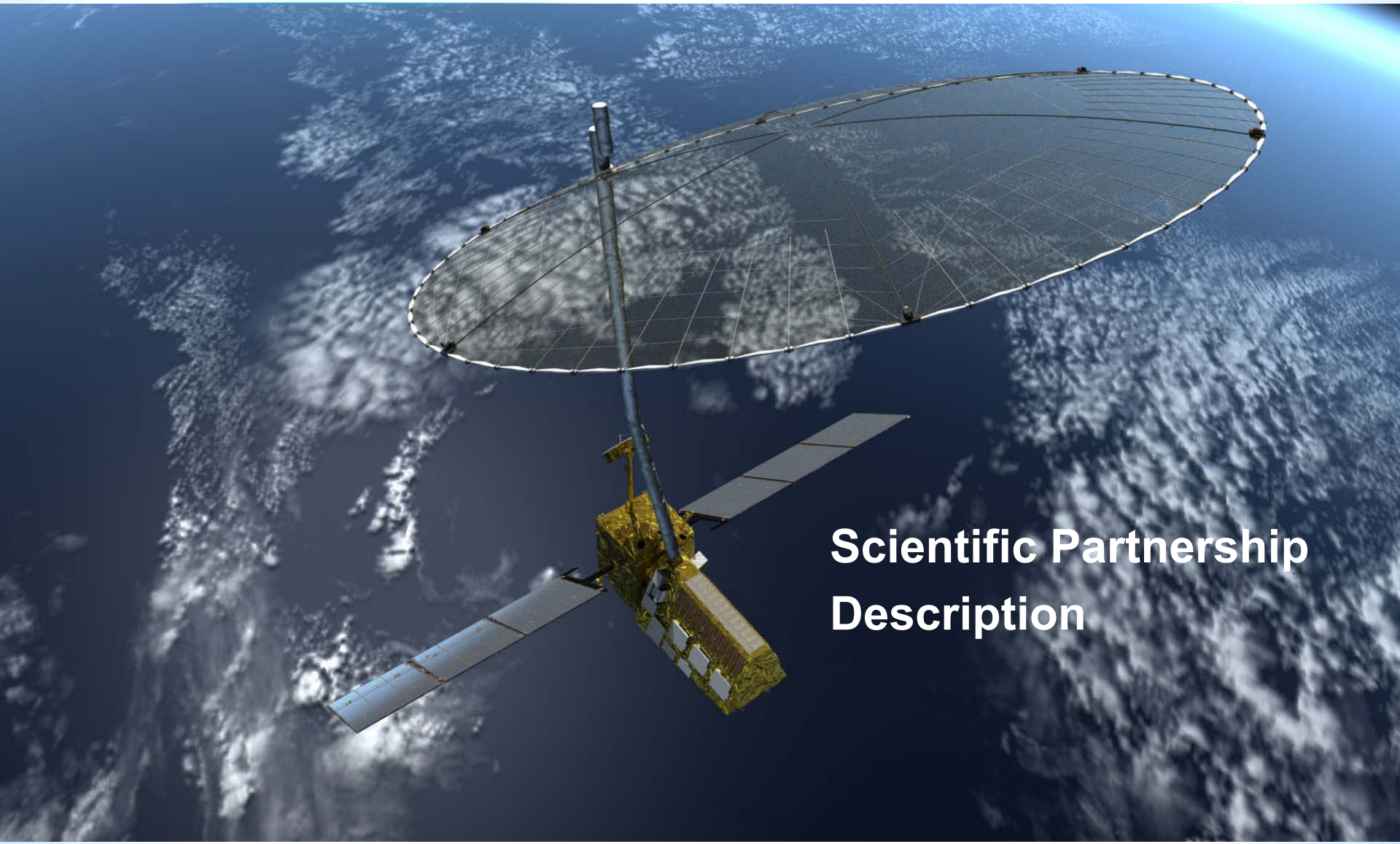

NASA
Jet Propulsion Laboratory
California Institute of Technology
इसरो isro
The NASA-ISRO SAR (NISAR) Mission Concept
Scientific Partnership Description
NI-SAR

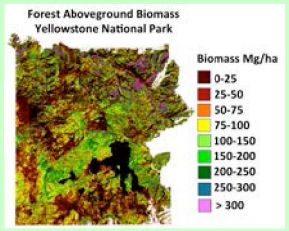
ALTERNATE TITLE SLIDE

The NASA-ISRO SAR (NISAR) Mission Concept



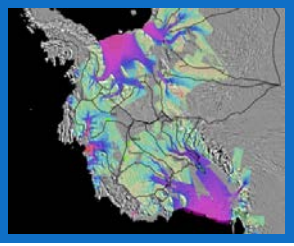
Science & Applications to Implementation

Ecosystems



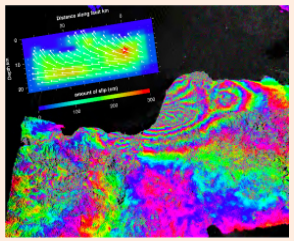
- Biomass, disturbance,
- Effects of changing climate on habitats and CO_2
- Agriculture

Ice Dynamics



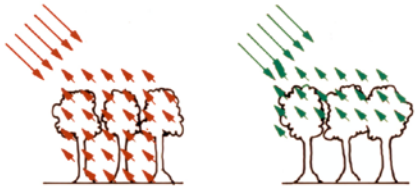
- Ice velocity, thickness
- Response of ice sheets to climate change & sea level rise

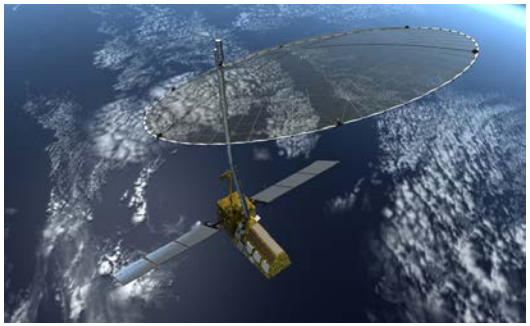
Solid Earth



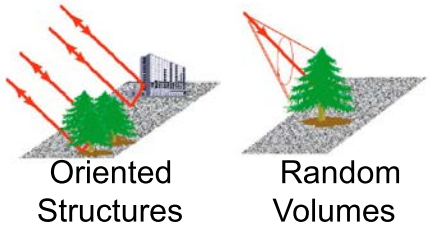
- Surface Deformation,
- Hazards Response,
- Water Resource Management

L- and S-band Wavelength

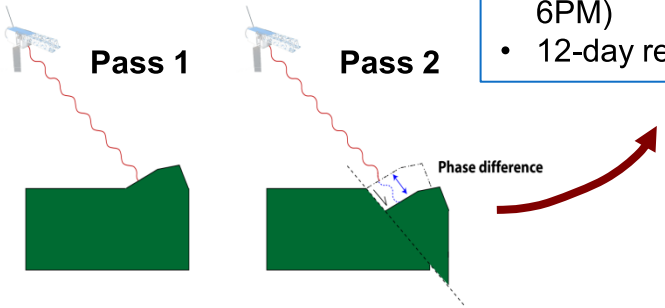




Polarimetry



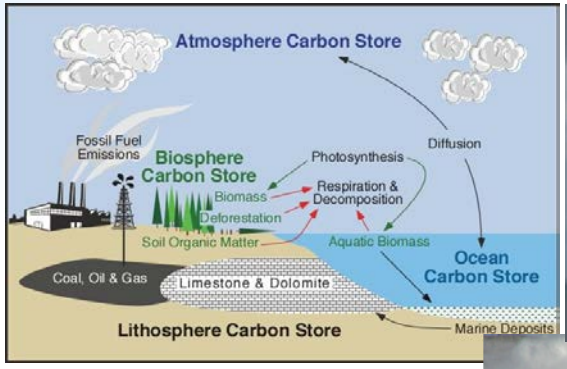
Repeat Pass InSAR

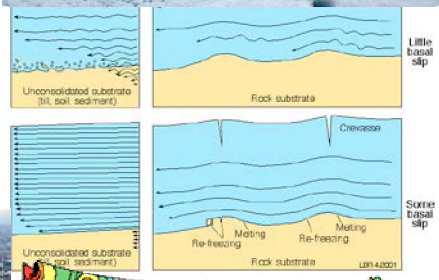


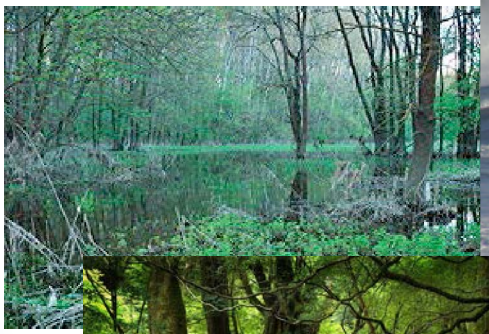
Mission Concept:

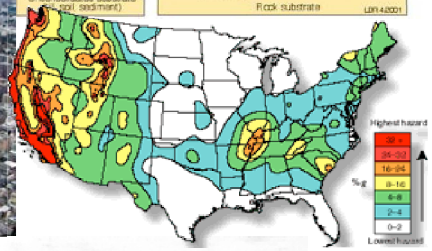
- L- and S-band SweepSAR with a large reflector
- 747km altitude, circular, 98 degrees inclination, sun-synchronous, dawn-dusk (6 AM-6PM)
- 12-day repeat

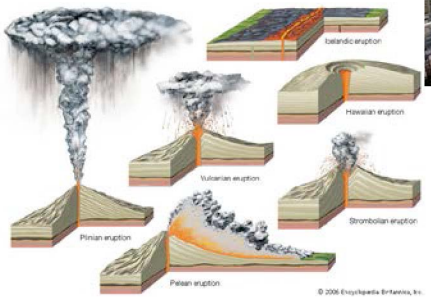
Critical Measurements for the US and Indian Science and Applications Communities





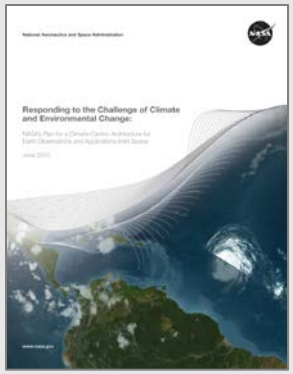






NASA-ISRO SAR Science Inspired by the 2007 NRC Decadal Survey and NASA Climate Architecture

- NRC Decadal Survey recommended a DESDynI Mission for near-term launch to address important scientific questions of high societal impact.
- NASA's Climate Architecture identified the radar's important role in climate (cryosphere and carbon) and water cycle science.

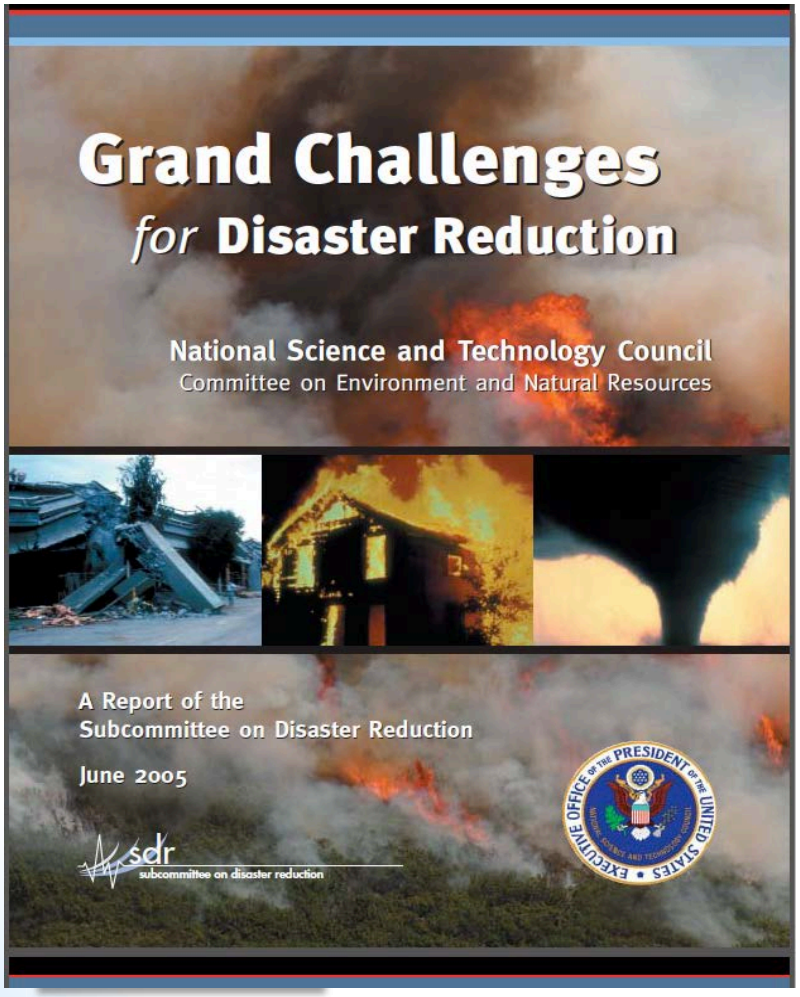


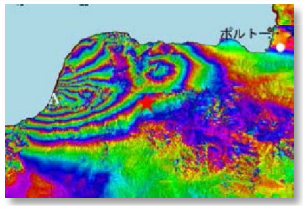
- The NASA/ISRO SDT has developed a set of integrated requirements to respond to the Climate Architecture and other important questions

- **Dynamics of Ice: Ice sheets, Glaciers, and Sea Level**
  - *Will there be catastrophic collapse of the major ice sheets, including Greenland and West Antarctic and, if so, how rapidly will this occur?*
  - *What will be the resulting time patterns of sea level rise?*
  - *How are alpine glaciers changing in relation to climate?*
- **Ecosystems and Biomass Change**
  - *How do changing climate and land use in forests, wetlands, and agricultural regions affect the carbon cycle and species habitats?*
  - *What are the effects of disturbance on ecosystem functions and services?*
- **Solid Earth Deformation – Hazard Response**
  - *Which major fault systems are nearing release of stress via strong earthquakes?*
  - *Can we predict future eruptions of volcanoes?*
  - *What are optimal remote sensing strategies to mitigate disasters and monitor/manage water and hydrocarbon extraction and use*
- **Coastal Processes – India**
  - *What is the state of important mangroves?*
  - *How are Indian coastlines changing?*
  - *What is the shallow bathymetry around India?*
  - *What is the variation of winds in India's coastal waters?*

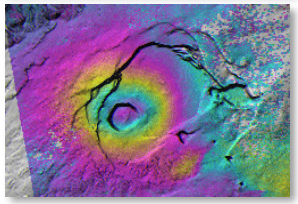
US and India Share Many Common Goals in Disaster Reduction and Mitigation

NI-SAR will support 9 of the 13 identified *Grand Challenge* hazards

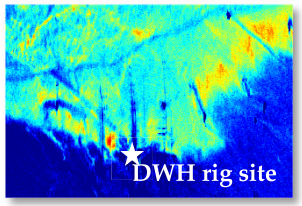




Earthquakes

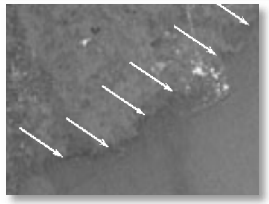


Volcanoes



Anthropogenic-Technological Disasters

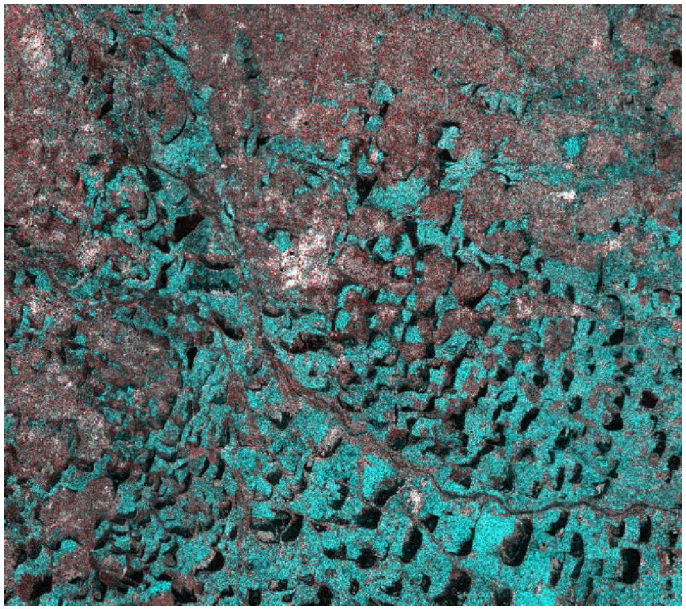
Floods



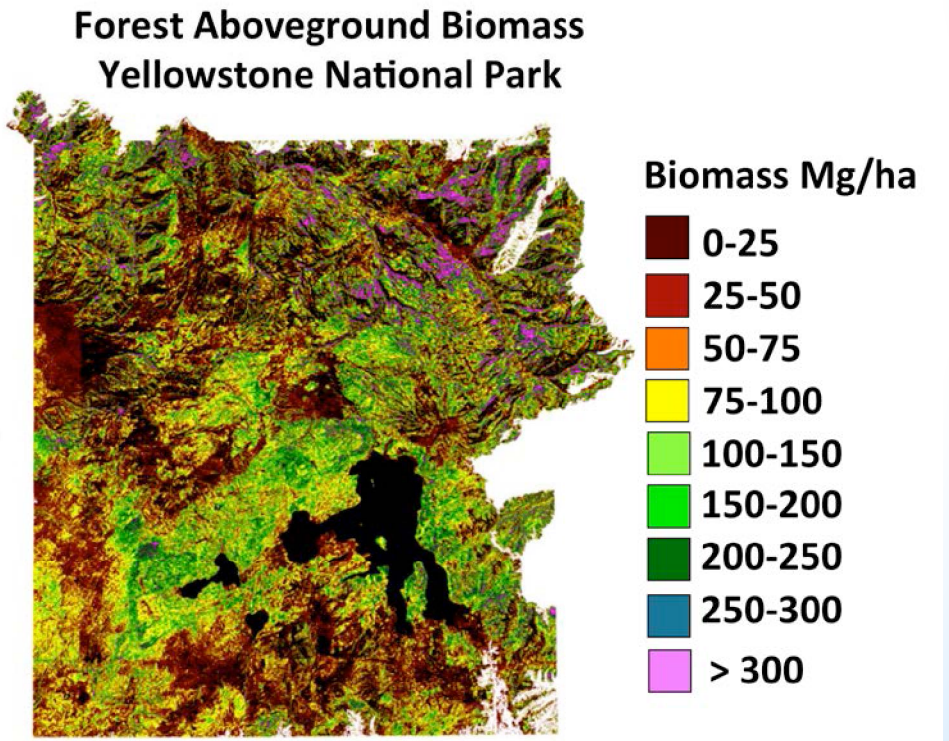
Coastal Inundation

NASA-ISRO SAR Mission Extends India's Science and Applications Programs

- RISAT-1, India's first SAR Mission, is best suited to monitoring light (low biomass) crops.
- The NASA-ISRO SAR Mission extends these capabilities to heavier crops and regenerating forests



RISAT-1 C-band Two-date composite of Sivaganga Area of Tamil Nadu showing Samba rice area (cyan colour)



NASA-ISRO L/S-band SAR Mission would enable higher density biomass estimates

Benefits of both US-contributed L-band SAR and India-contributed S-band SAR

- *Global* L-band data with unprecedented spatial and temporal sampling will drive new directions in science and applications
- *Globally distributed but targeted* S-band data for science applications would be a fundamentally new data set

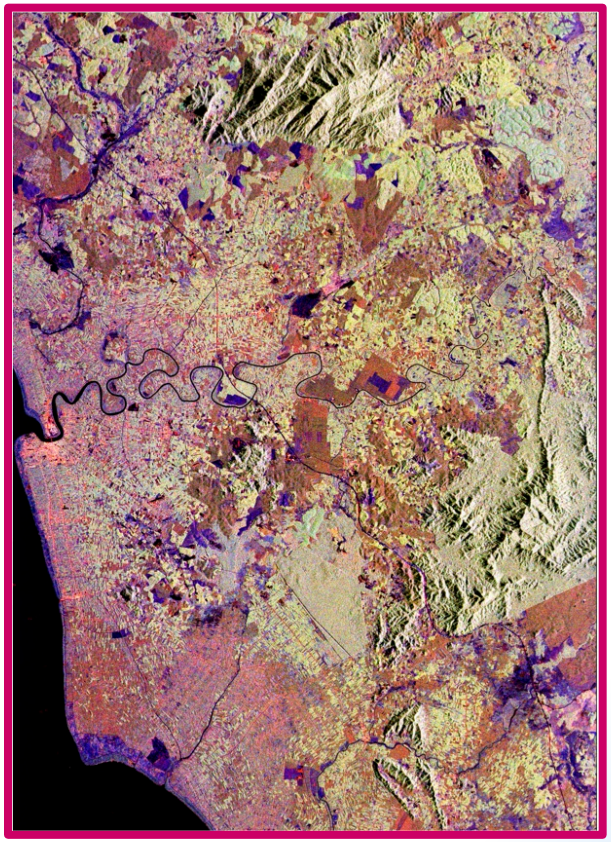
Wheat Fields,

Dnieper River, Ukraine

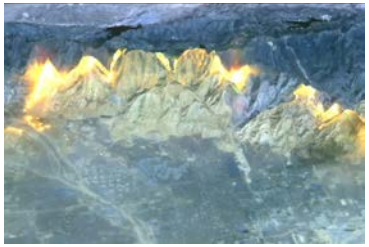
Red: LHH
Green: LHV
Blue: CHV

Rubber, banana, and oil palm trees,

Muar, Malaysia



The NASA-ISRO SAR Mission Captures the Earth in Motion

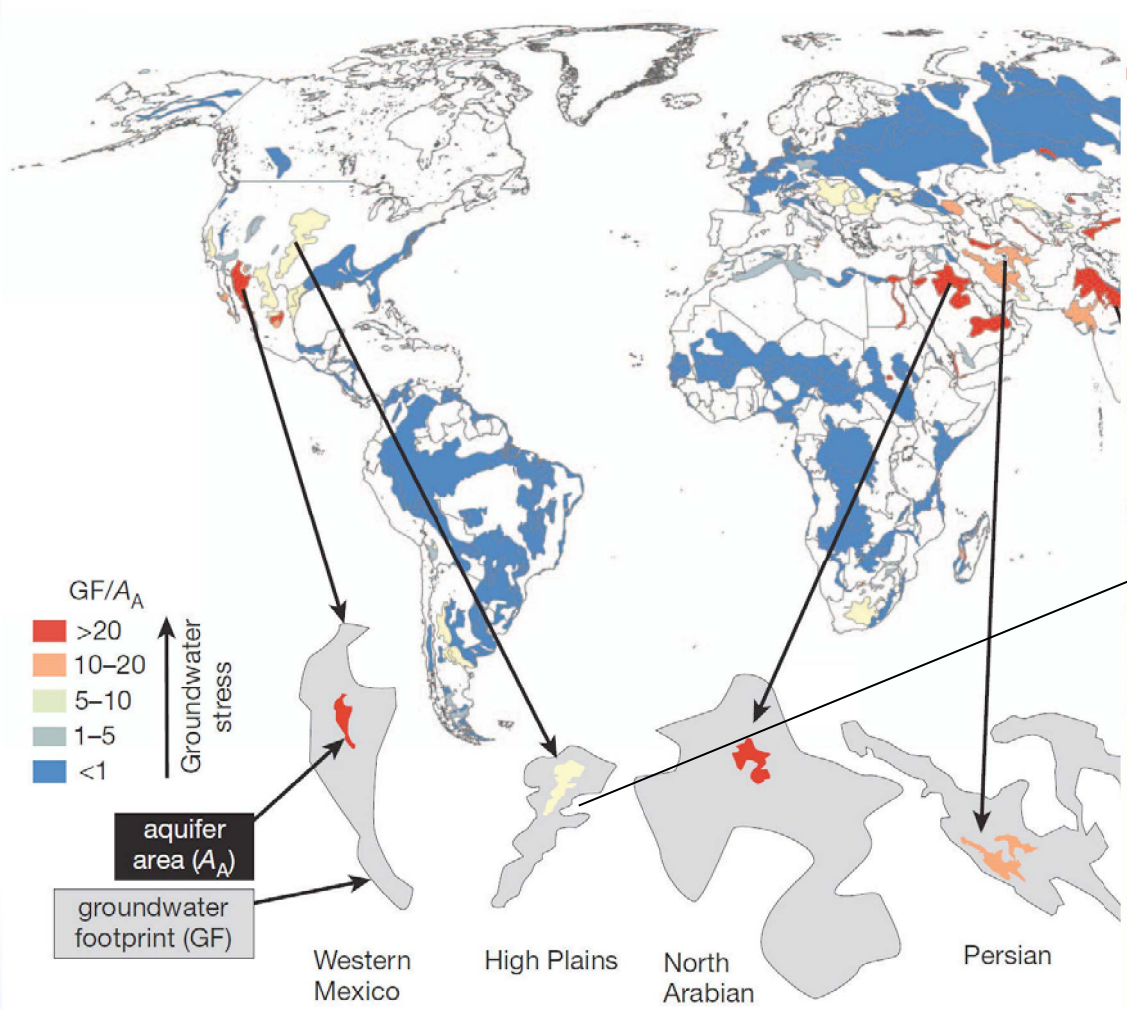


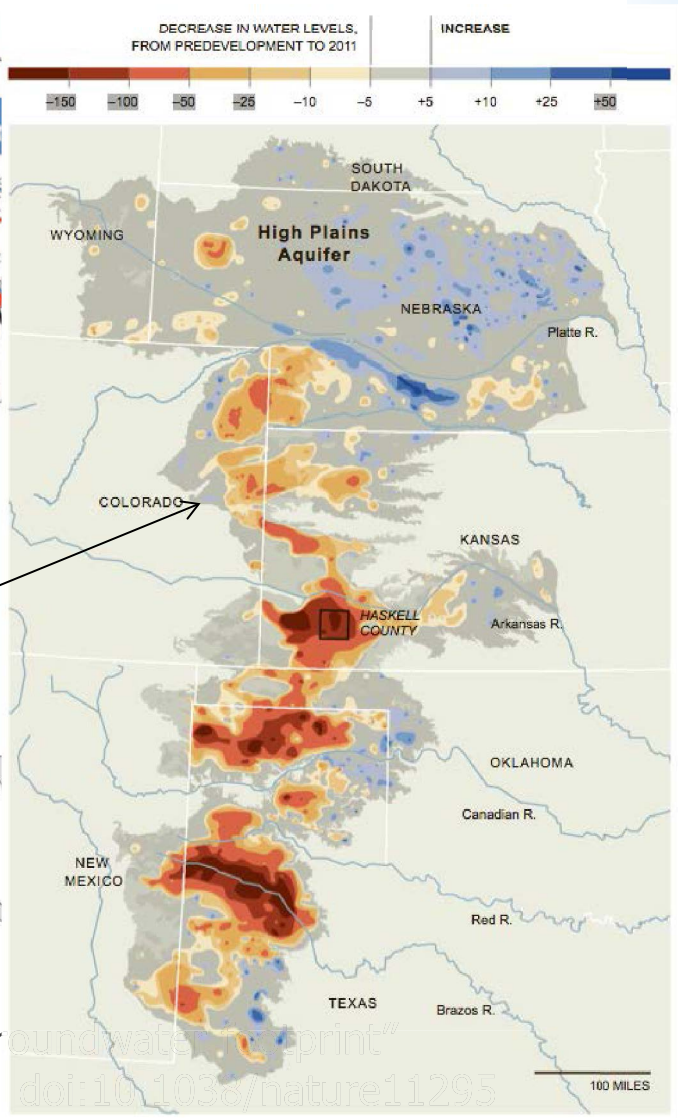
- *Dense temporal and spatial sampling*
  - Reveals the mechanisms that drive poorly understood surface processes
    - Fast-transients on Ice sheets and glaciers
    - Disturbance and recovery in forests
    - Tracking evolving hazards
- *Comprehensive* global measurements
  - Of ice to improve climate projection accuracy
  - Of ecosystems to reduce land carbon flux uncertainties
  - Of solid earth to improve disaster forecasting and risk assessments
- *Targeted* regional measurements
  - New science
  - New applications
  - Hazard response

Societal Challenges and What a NASA-ISRO SAR Could Contribute

Challenge	SAR Benefit Through Regular Monitoring of:
Global Food Security	- Soil moisture and crop growth at agricultural scale - Desertification at regional scales
Freshwater Availability	- Aquifer use/extent regionally - Water-body extent changes - Glaciers serving as water sources
Human Health	- Moisture and vegetation as proxy for disease and infestation vectors
Disaster Prediction & Hazard Response	- Regional building damage and change assessment after earthquakes - Earthen dams and levees prone to weakening - Volcanoes, floods, fires, landslides
Climate Risks and Adaptation	- Ice sheet/sea-ice dynamics; response to climate change - Coastal erosion and shoreline migration
Urban Management and Planning	- Urban growth through coherent change detection - Building deformation and urban subsidence
Human-activity Based Climate Change	- Deforestation's influence on carbon flux - Oil and gas reservoirs

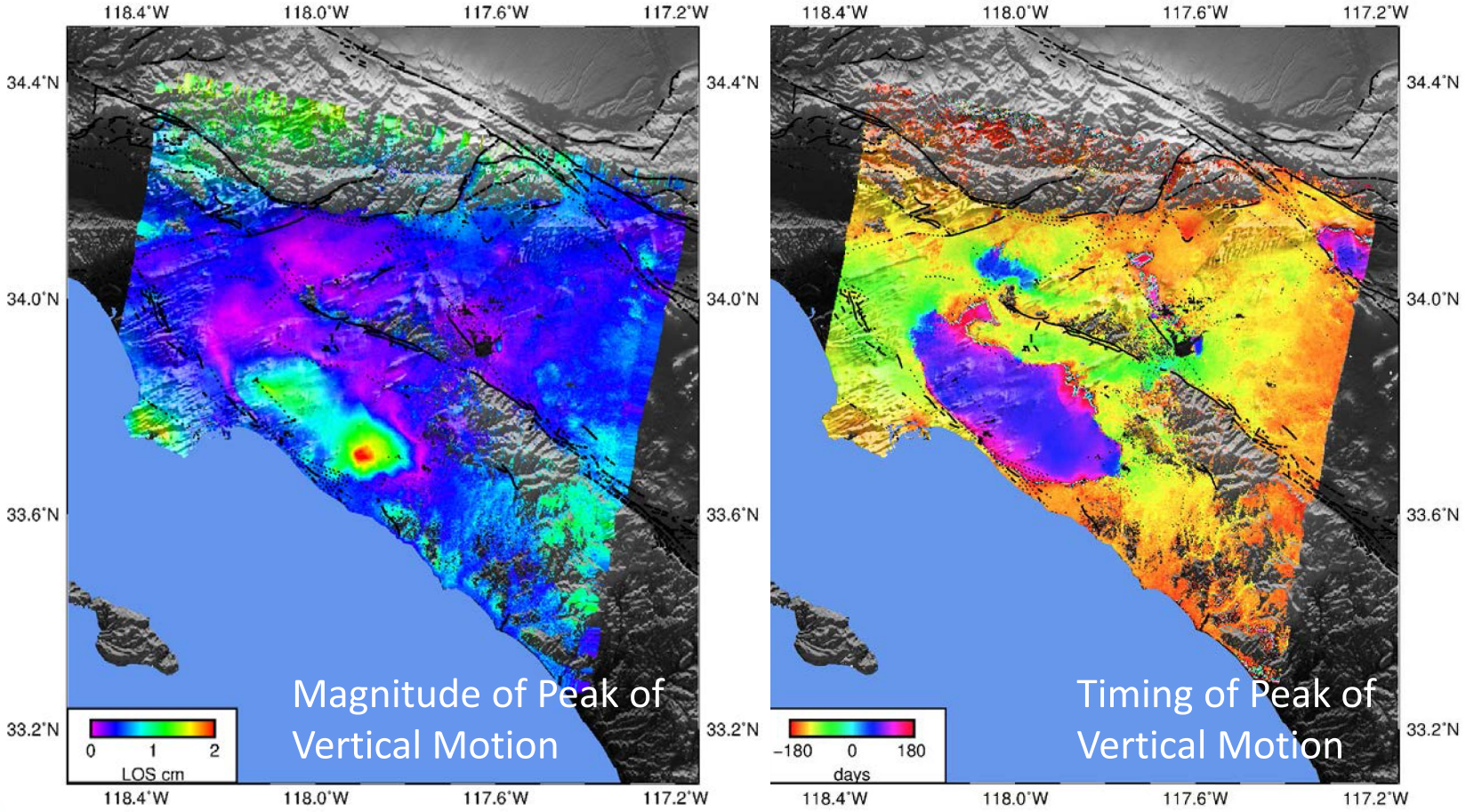
Locations of the World's Aquifers





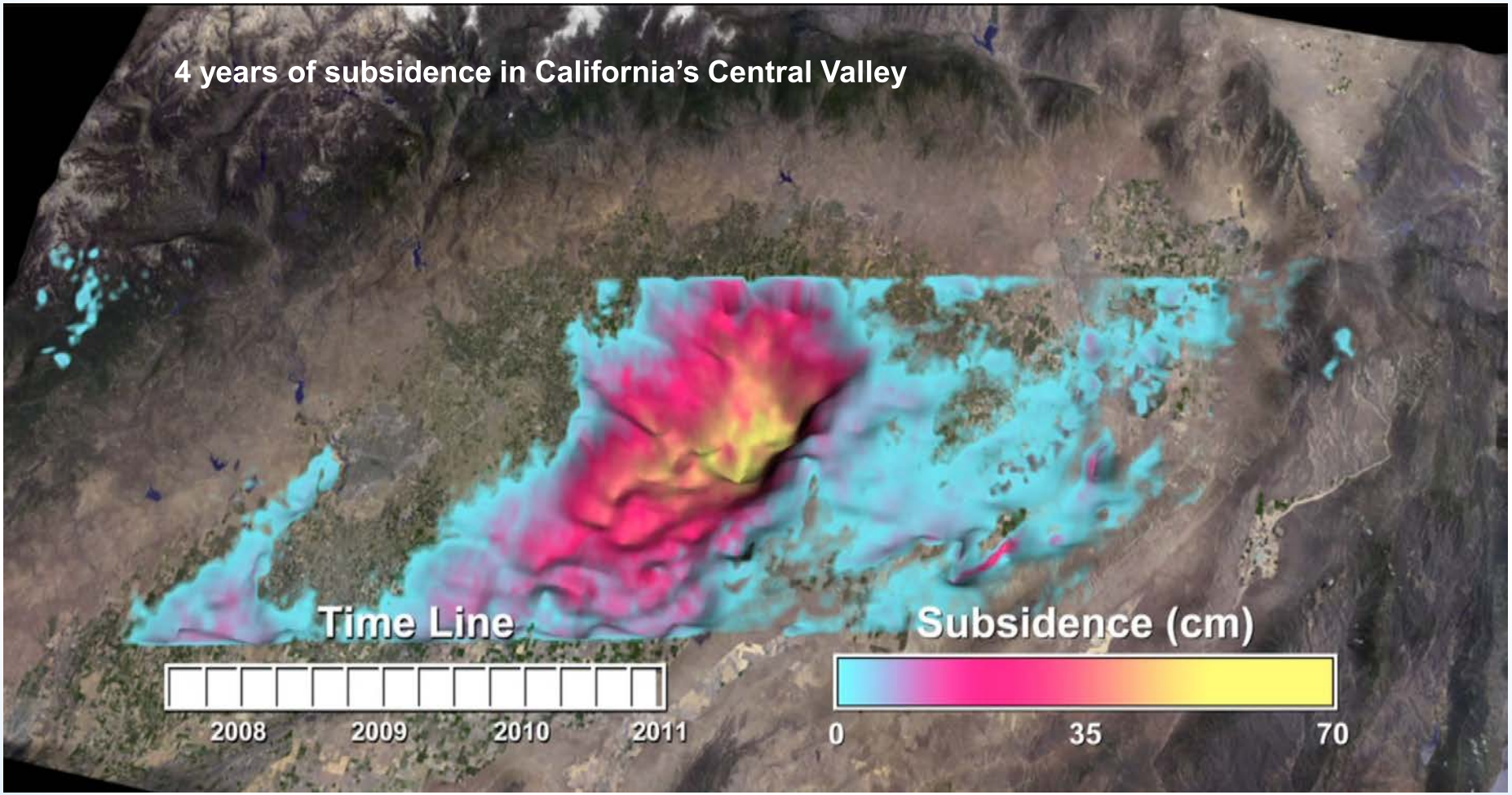
"Water balance of global aquifers revealed by gr[illegible]groundwater footprint"
Gleeson, T., et al. (2012) Nature 488, 197–200 doi:10.1038/nature11295

NASA-ISRO SAR for Understanding Potential Changes in Available Water Resources



Agram et al (2013), New Radar Interferometric Time Series Analysis Toolbox Released, EOS Trans. AGU, 94(7), 69. Website: http://earthdef.caltech.edu

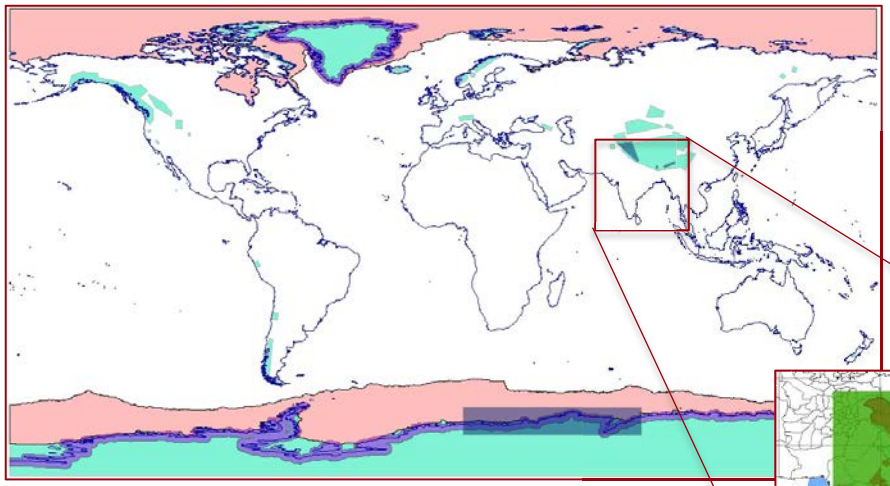
NASA-ISRO SAR for Understanding Potential Changes in Available Water Resources



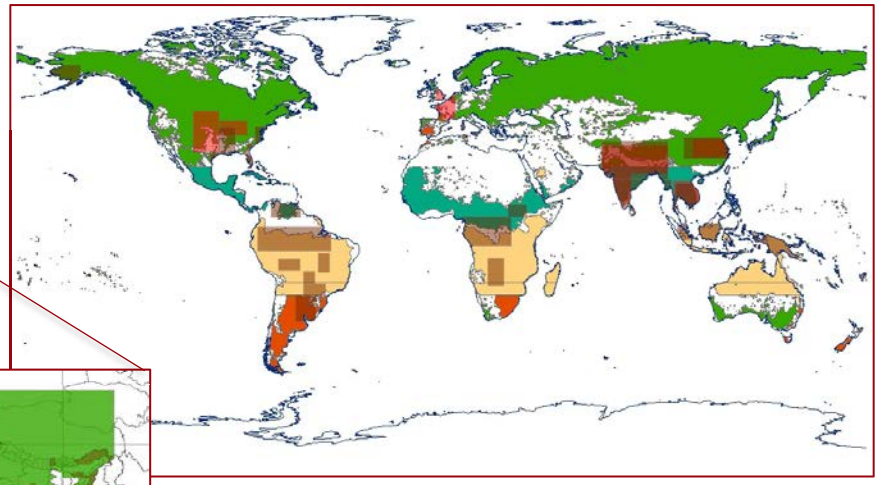
NASA-ISRO-SAR could measure subsidence globally, determining stressing of aquifers

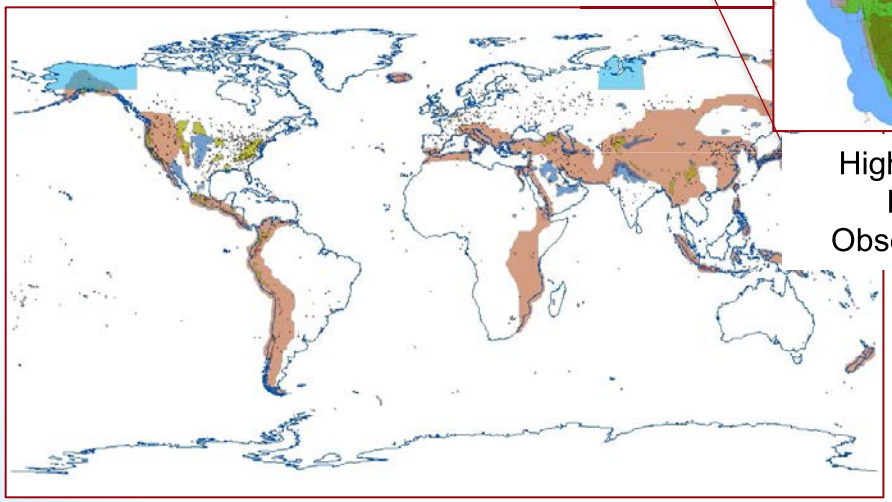
NASA-ISRO Comprehensive Observations Plan Exploiting L- and S-Band Radars

Global Ice Sheet and Glacier

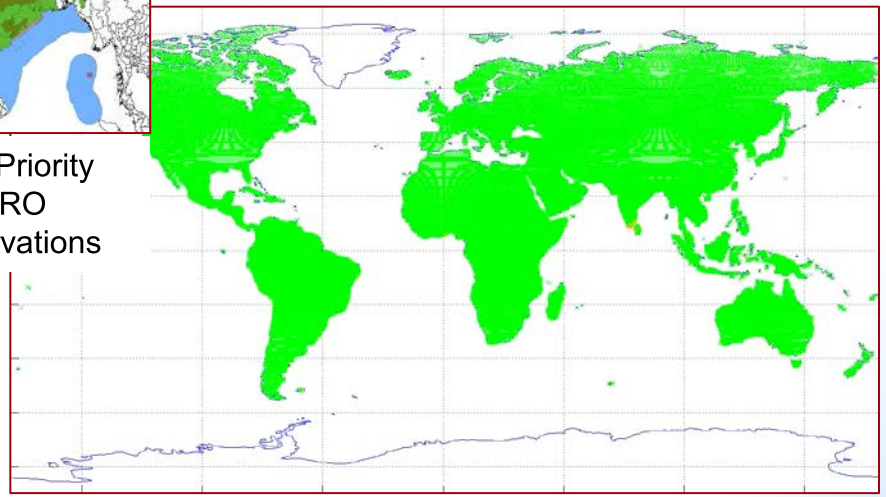


Global Vegetation Cover





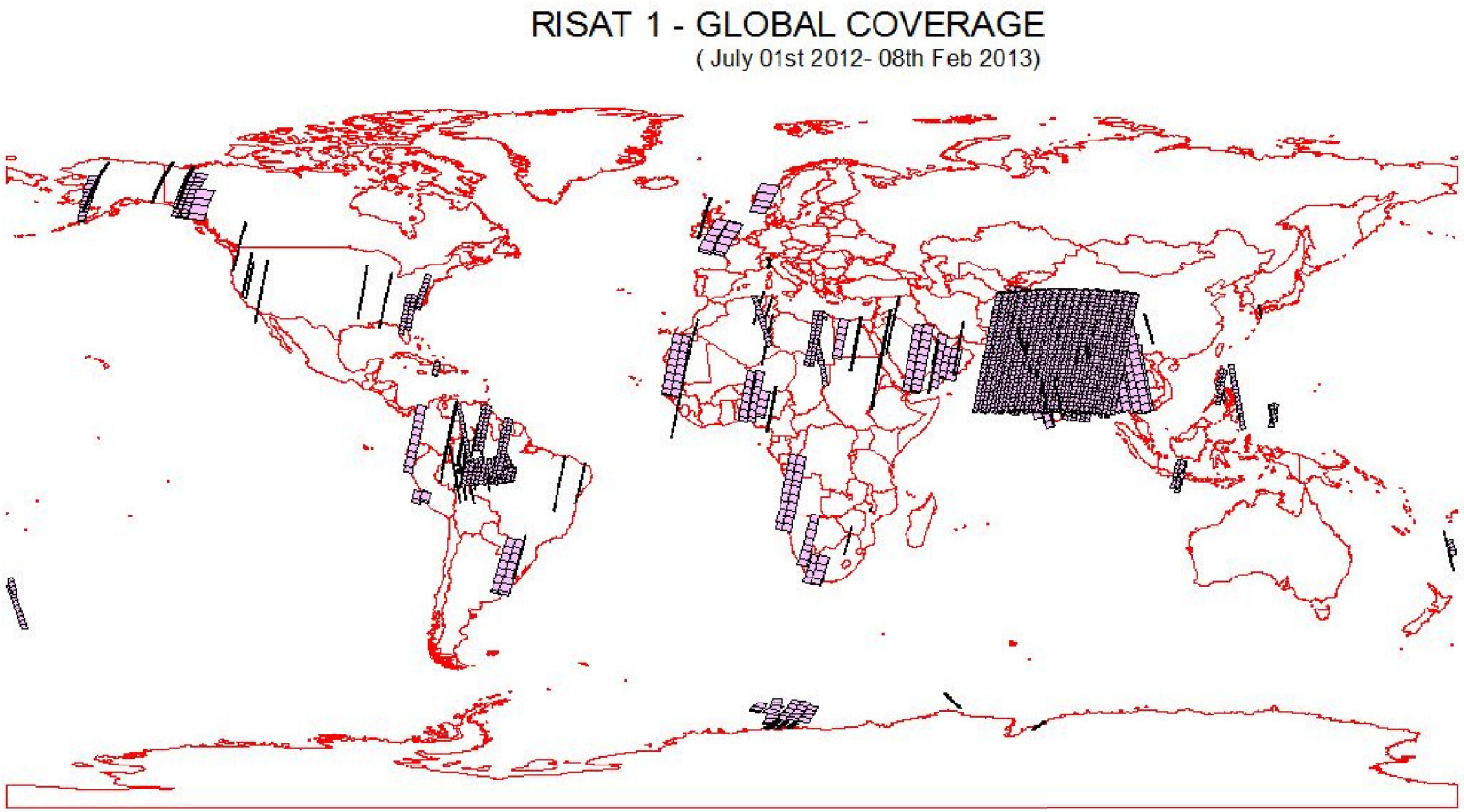
High Priority ISRO Observations



Global Deformation Science Areas

Global Background Mission

India's RISAT-1 C-band SAR Mission Coverage



- NASA-ISRO SAR Mission provides synergistic measurements over India and a global reach beyond.

Convergence of National Civilian SAR Observing Programs

Earth

SeaSAT

Challenger

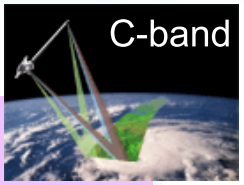
SIR-A SIR-B

SIR-C/ X-SAR

SRTM

L/C/X-band

C-band



NASA-ISRO SAR Mission

L/S-band

L-band

Magellan

Launch Orbit

Cassini Planetary

Launch Orbit

LRO

Chandrayan

L/S-band

S-band

Ku-band

X-band

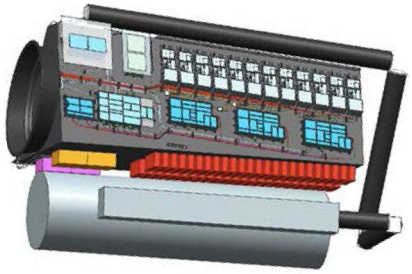
RISAT-2

RISAT-1

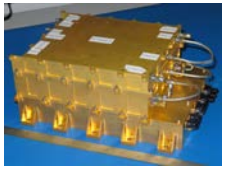
C-band

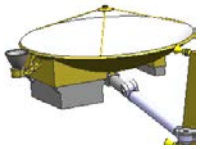
1980 1985 1990 1995 2000 2005 2010 2015

ISRO NASA Work Share

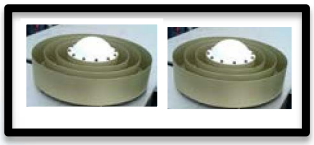


L-band SAR electronics
Instrument structure
Reflector boom assembly



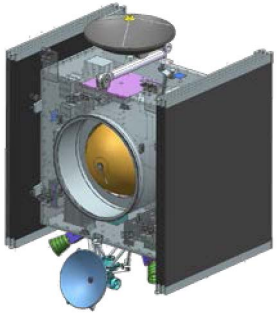


High data rate telecom



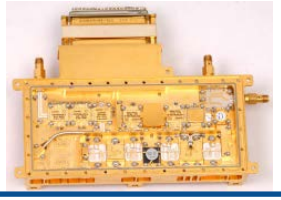
GPS

High capacity
solid state recorder



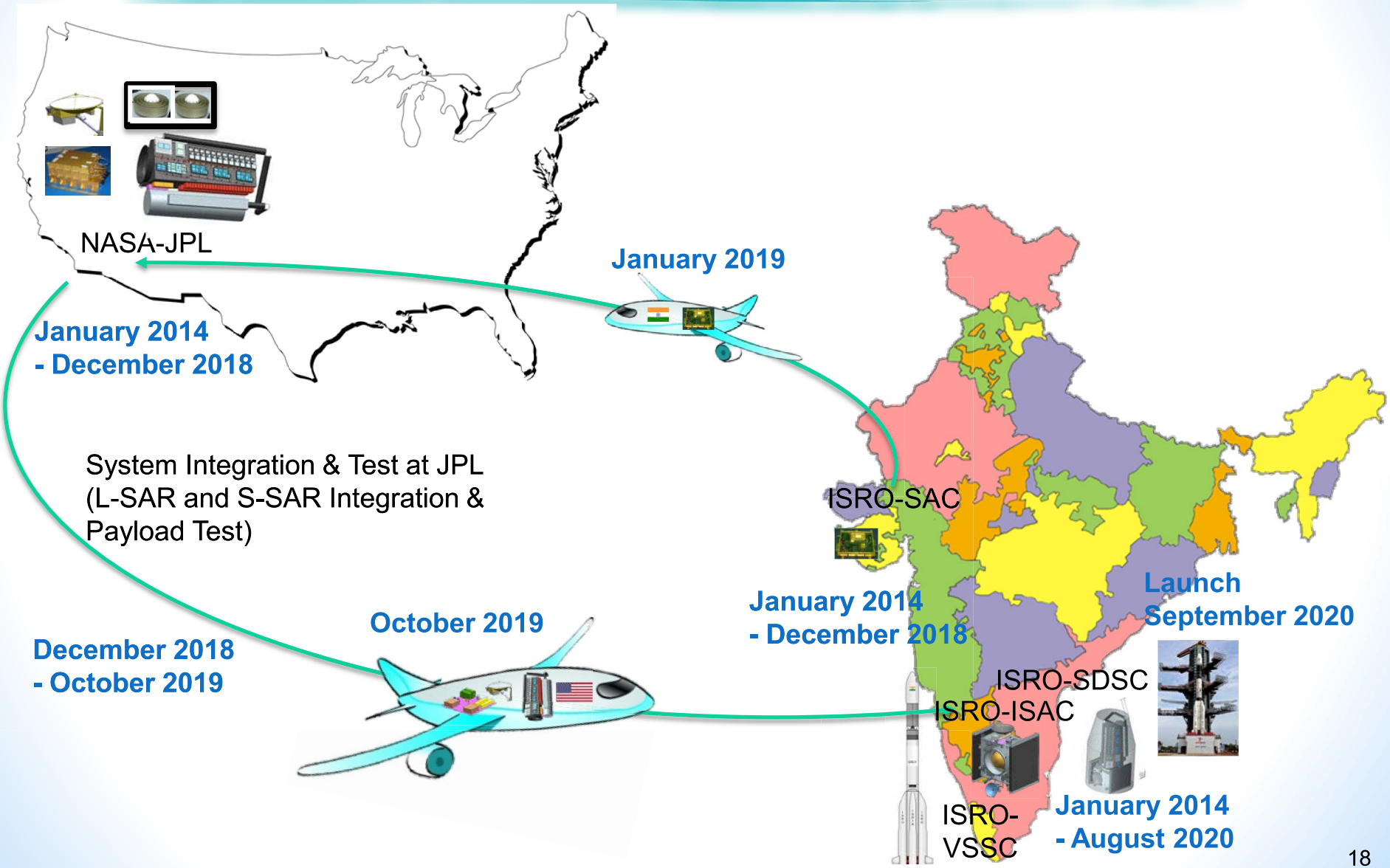
Spacecraft (I3K)

Launch vehicle (GSLV)



S-band SAR electronics

Observatory Development Flow



Next Steps for NASA-ISRO SAR Mission

- Letter of Interest (drafted by NASA)
- Technical Interface Meetings November 2013
- ISRO Project Team Formation December 2013/January 2014
- NASA Mission Phase A start January/February 2014
- ISRO Baseline Design Review February/March 2014
- Letter of Agreement Prior to NASA System Requirements Review/Mission Definition Review (SRR/MDR)
- NASA SRR/MDR October 2014
- NASA Mission Phase B start December 2014
- NASA, ISRO, JAXA meeting to define science requirements for a proposed joint scatterometer mission November 2013
- Continued discussions on collaborations on Mars:
  - Possibility to carry the Electra payload and science instruments on ISRO mission to Mars in 2016 or 2018
  - Support for EDL for a future ISRO lander in addition to the DSN and navigation support that we have provided for their current Mars mission (MOM).

Summary

- Exciting scientific returns in three distinct science disciplines by exploiting the power of wide-area mapping radar
- Direct benefits to society as its measurements are used to help forecast sea level rise, the likelihood of earthquakes or volcanic eruptions and to improve forest inventories and carbon monitoring
- Unique data available to the world for scientific use
  - Accuracy/resolution/coverage orders of magnitude improvement over existing systems
  - Free and open data policy

NI-SAR Partnership

- Discussions between NASA and ISRO started from July 2011.
- In January 2012, the JPL team visited ISRO and developed a dual frequency (L- and S-band) mission concept.
- Science data from both L- and S-band SAR will be available to each partner without any restrictions.
- The ISRO team and the JPL team have worked closely to develop a mission concept from January 2012 to now.
- ISRO received approval from the Government of India for jointly developing Dual frequency (L- and S-band) SAR.
  - TAA between ISRO and Caltech/JPL has been enacted.
- The NI-SAR team passed the Mission Concept Review in October 2013.

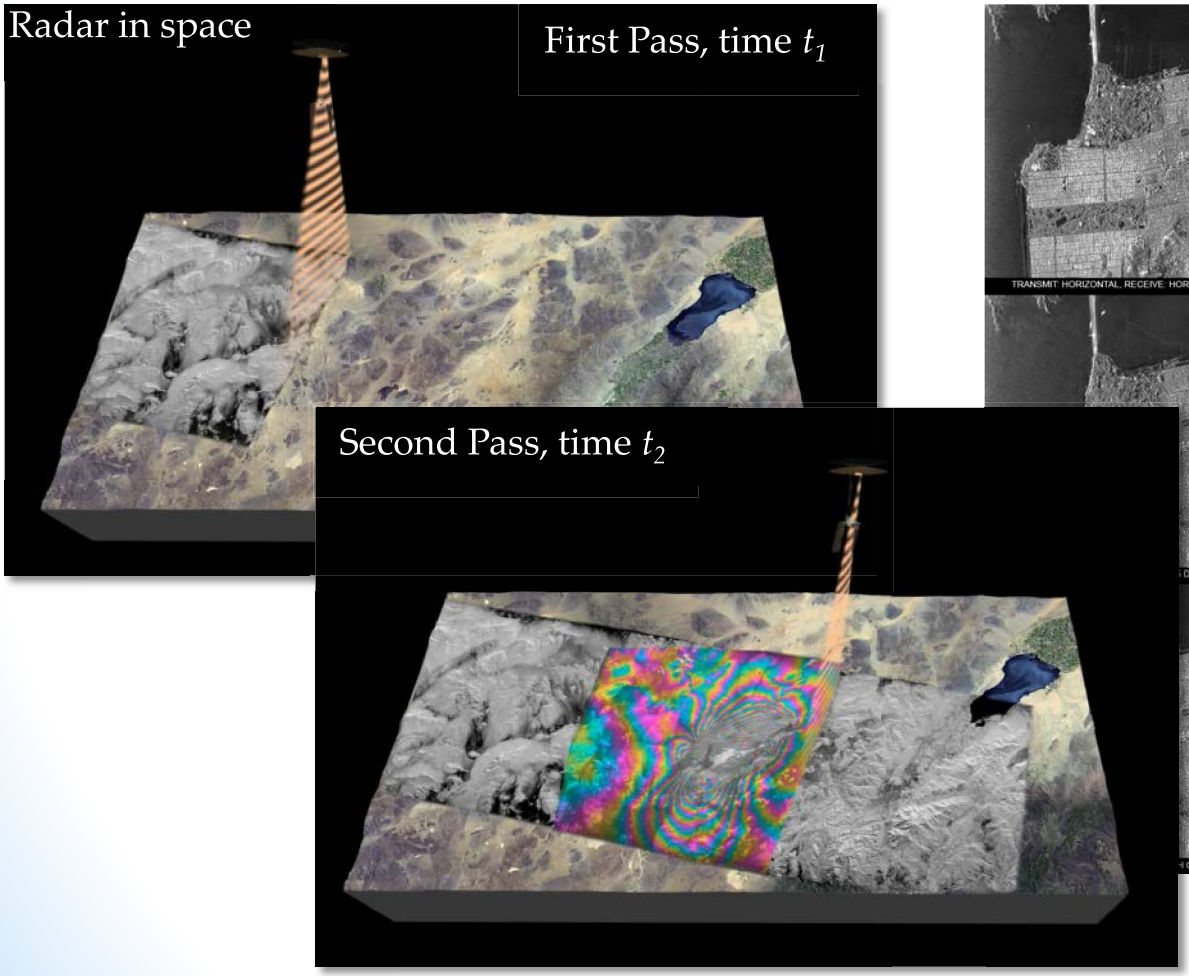
ISRO Observation Requirements beyond Global L-band Observation Plan

Objective	Wavelength	Region of Interest	Repeat Frequency	Modes
Coastal Erosion	L or S	Regions of India	Half-yearly	HH/HV
Mangroves	L or S	Coasts of India	Half-monthly for 4 mos.	DP - QP
Tide Lines	L or S	Regions of India	Selective Monthly	HH/HV
Bathymetry	L or S	Off-shore of India	Half-yearly	VV
Wave Spectra	L or S	Global distribution	Weekly	VV
Coastal Winds	L or S	Regions of India	Weekly	VV/HH
Sea-ice Thickness	L and S exp*	Defined polar targets	Half-monthly	DP – QP
Mountain Glaciers	L and S exp*	Himalayas	Half-monthly	DP – QP
Alpine Vegetation	L and S exp*	Himalayas	Half-yearly	DP – QP
Soil Moisture	L exp*/ S exp*	Regions of India	Weekly	DP – QP
Land Subsidence	L and S exp*	Regions of India	Monthly	HH
Landslides	L and S exp*	Regions of India	Weekly in rainy season	HH

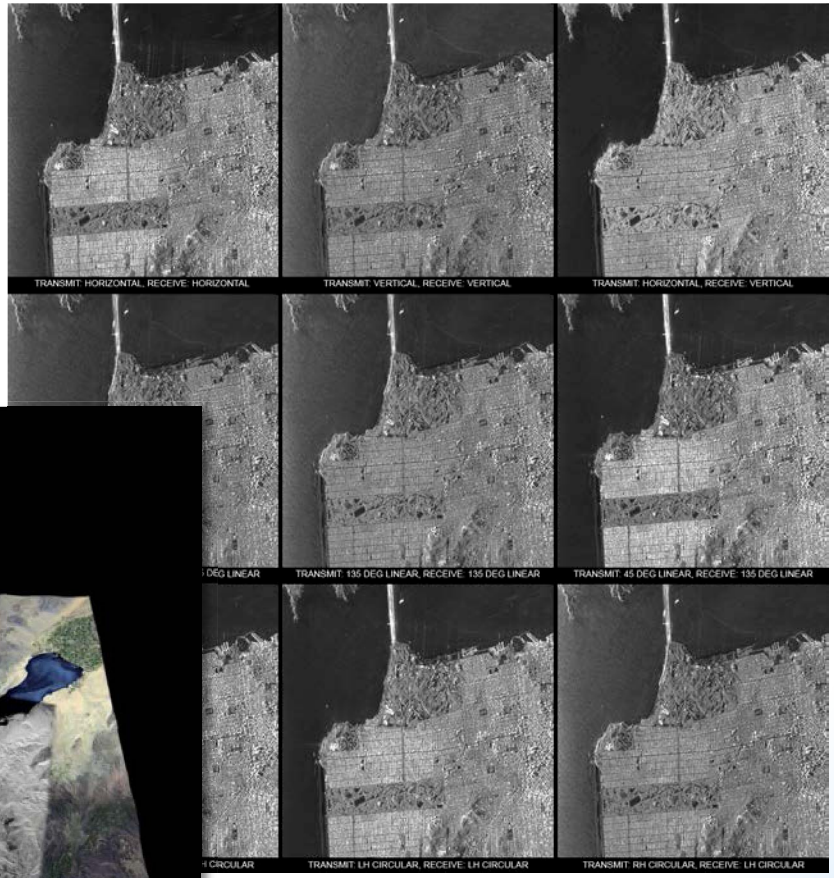
*exp – experimental

NI-SAR Measurements to Achieve Science Objectives

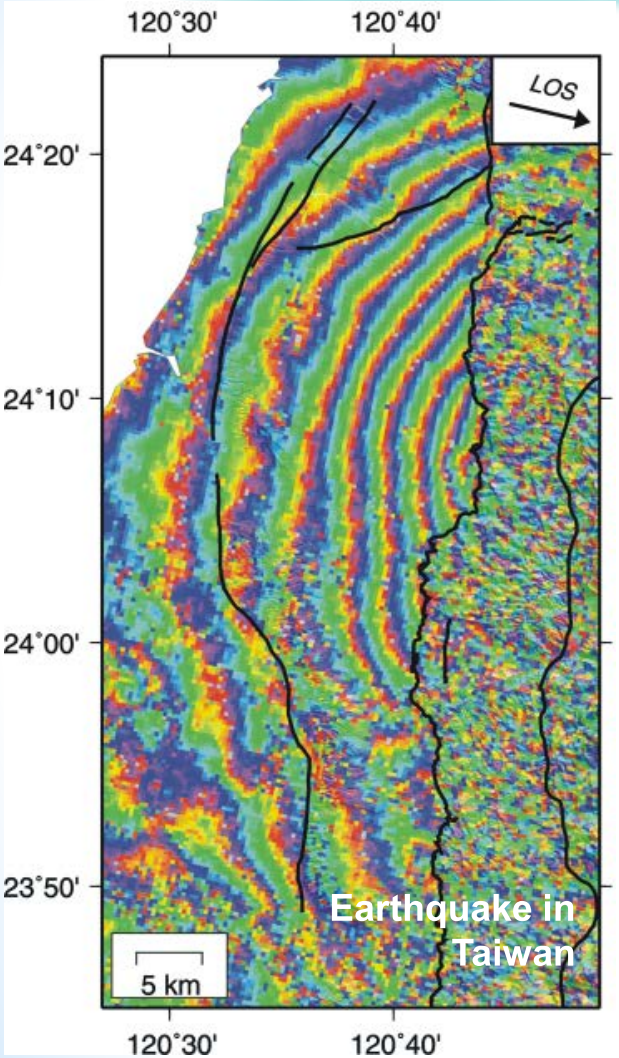
Repeat Pass Interferometry



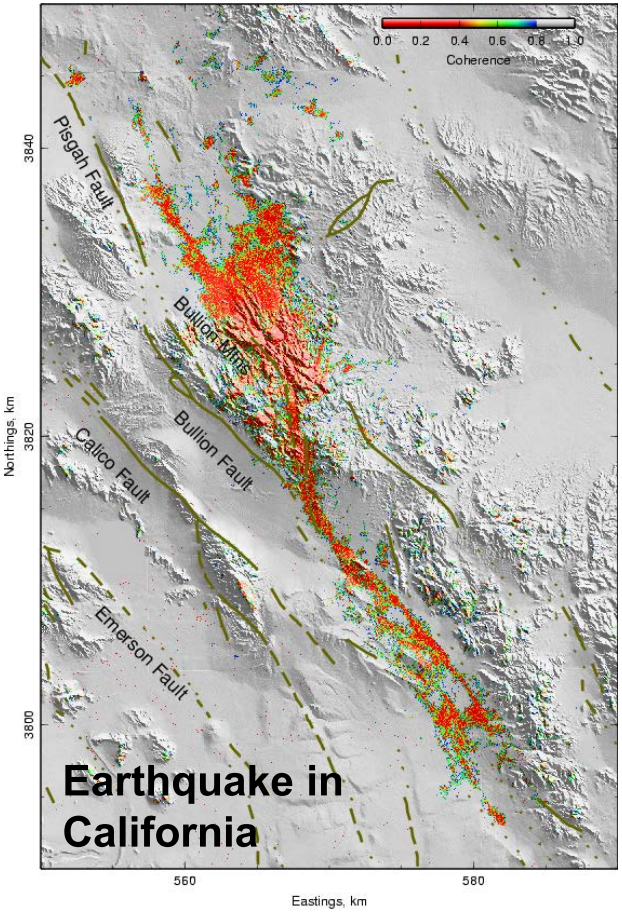
Polarimetric Diversity



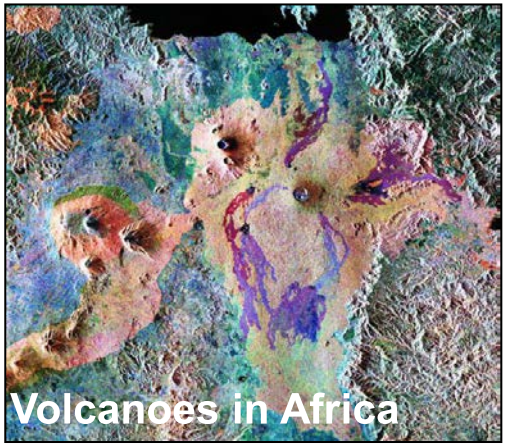
Basic Geodetic & Imaging Measurements

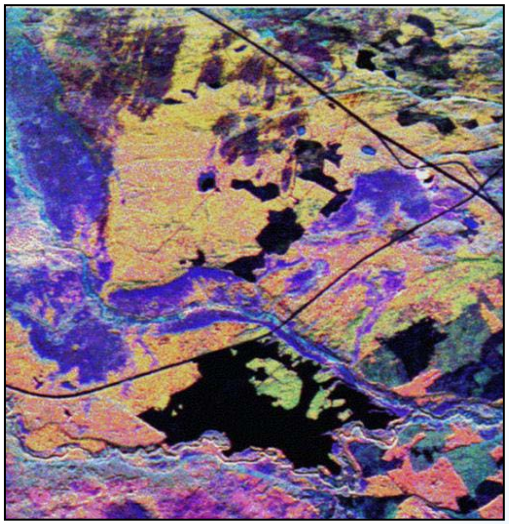


Interferogram –
How much motion?



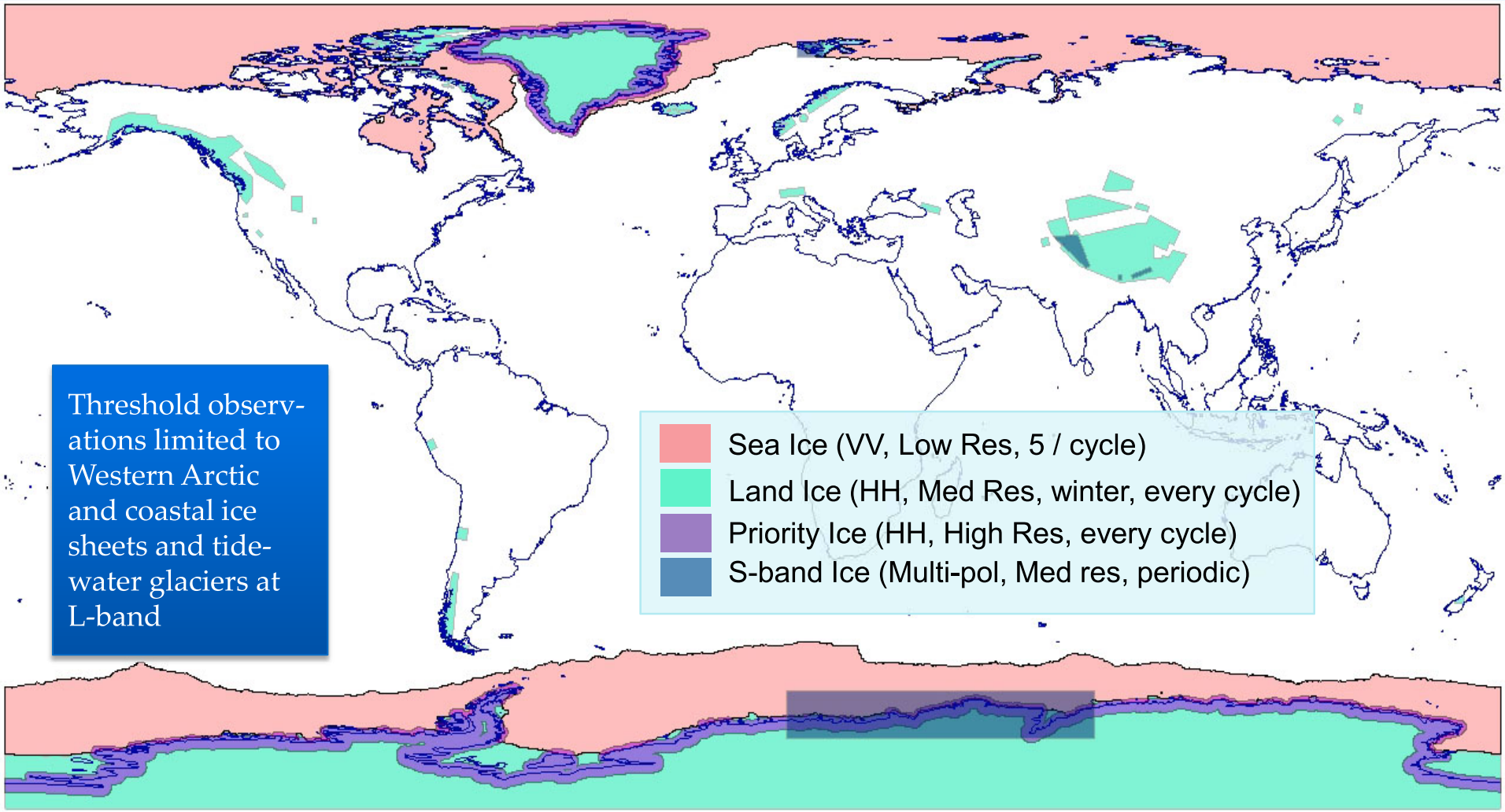
Decorrelation –
How severe the change?



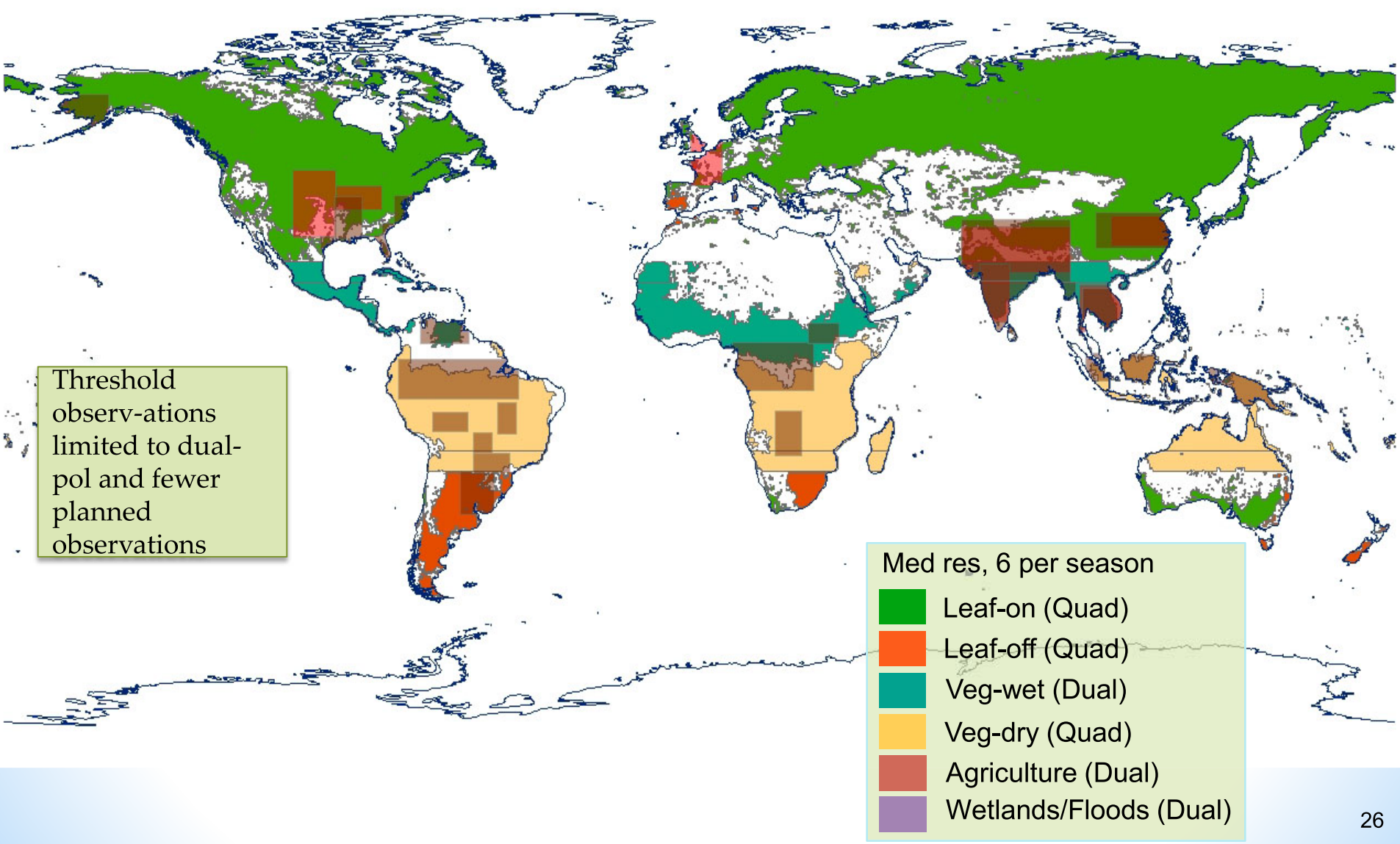


Polarimetry –
How much carbon?

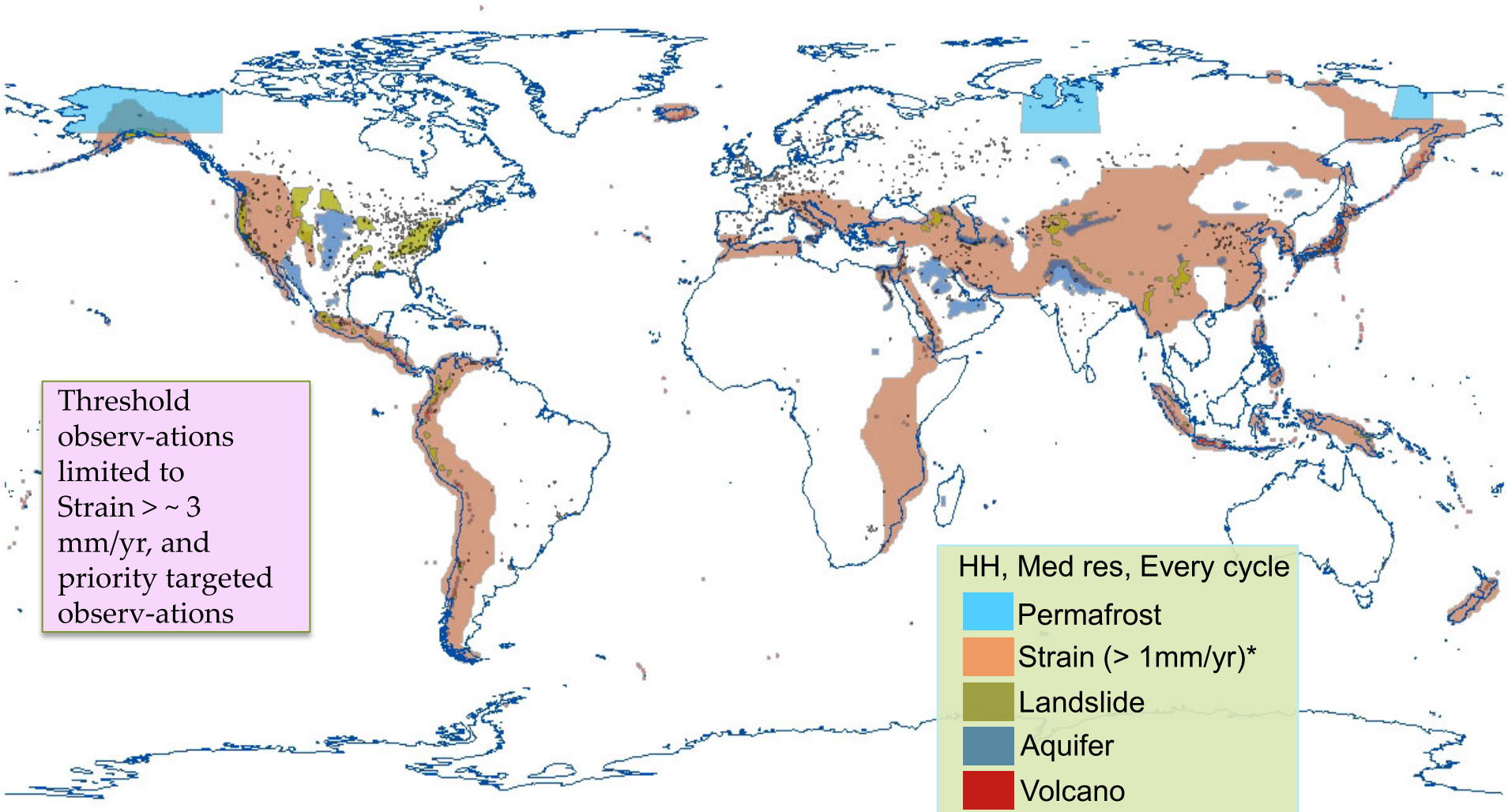
Dynamics of Ice Baseline Observations – L- and S-Band Coverage



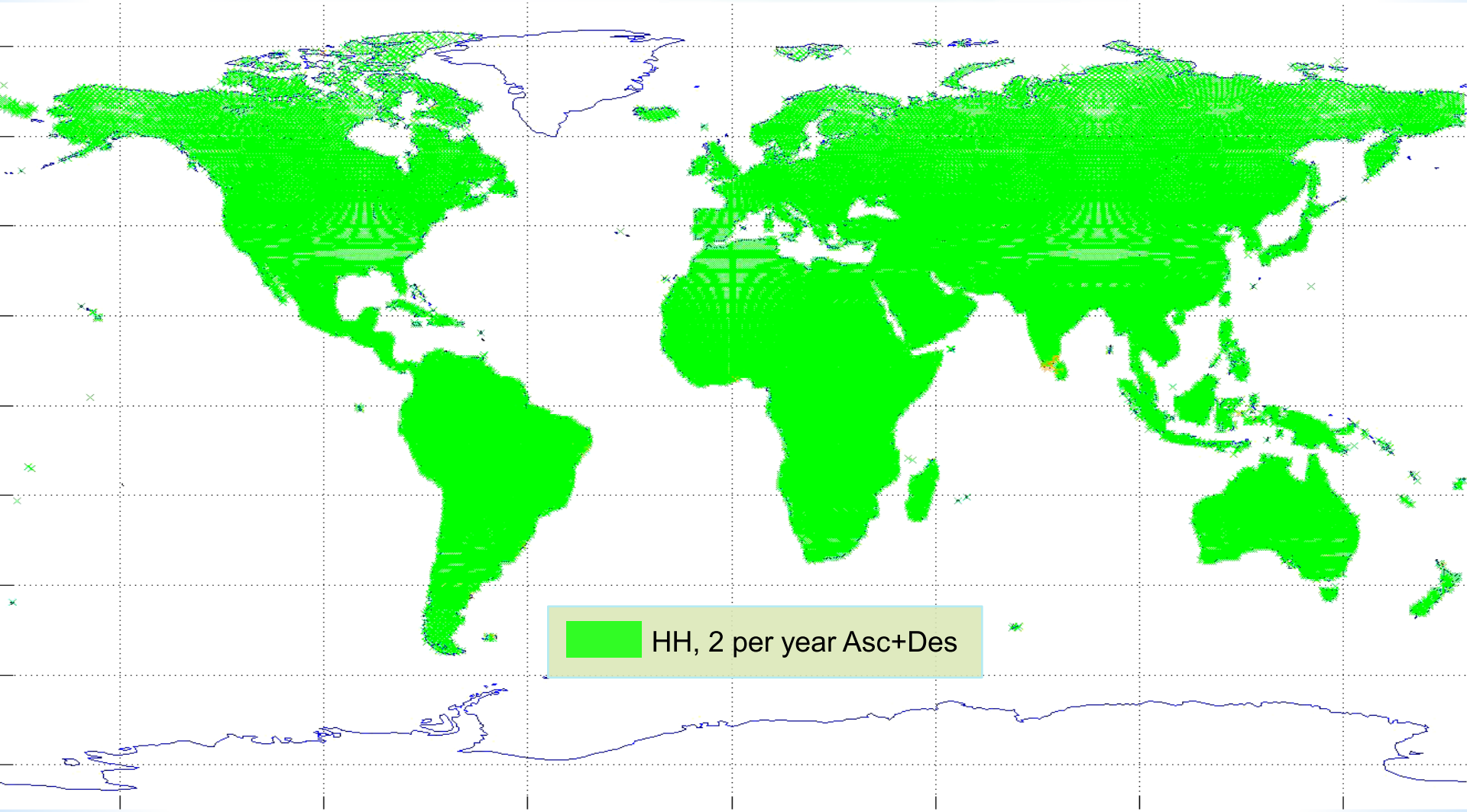
Ecosystems Baseline Observations – Multi-Pol Seasonal Sampling



Solid Earth Deformation and Targeted Baseline Observations



Solid Earth Deformation Baseline Observations – L-Band Base Map Coverage



ISRO-Unique Non-Ice Observations