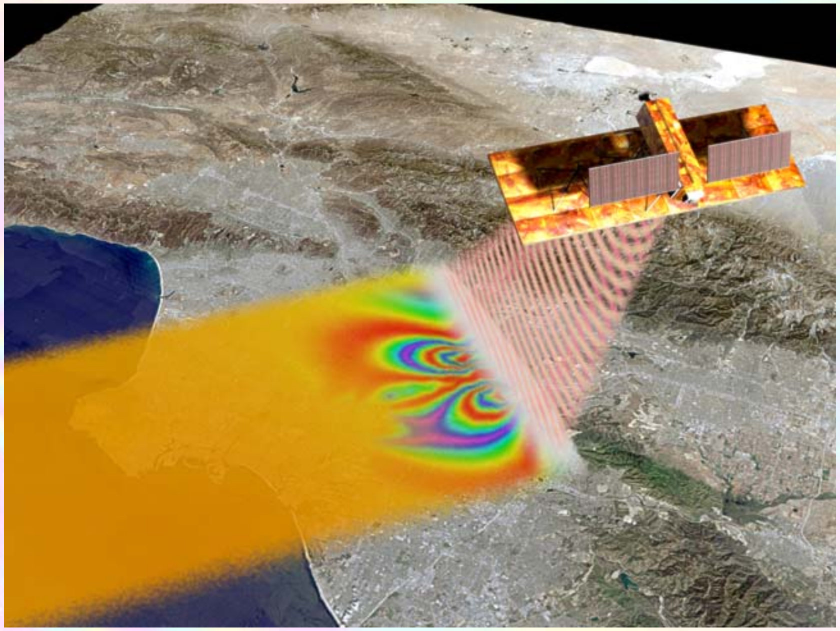
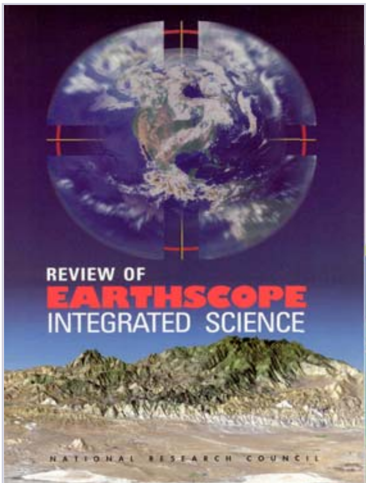
Interferometric Synthetic Aperture Radar (InSAR) and GGOS



Andrea Donnellan
NASA/JPL
February 21, 2007

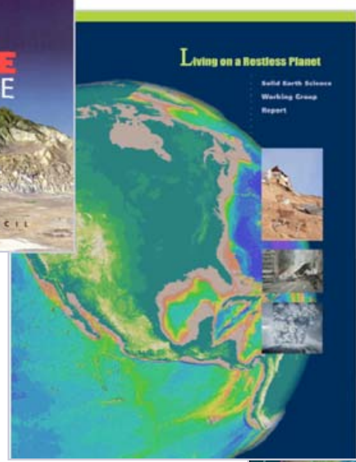
Sources for Science Objectives

…as captured in the NASA Science Plan



Fourth component of EarthScope

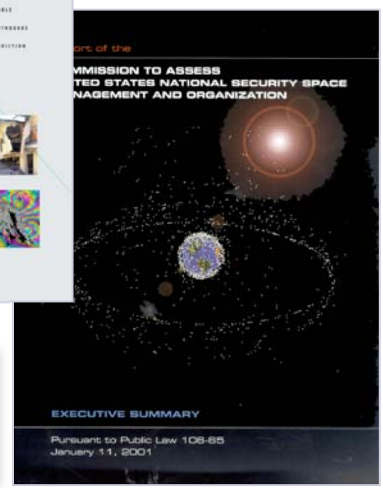
Involvement:
NSF, NASA, USGS, Universities



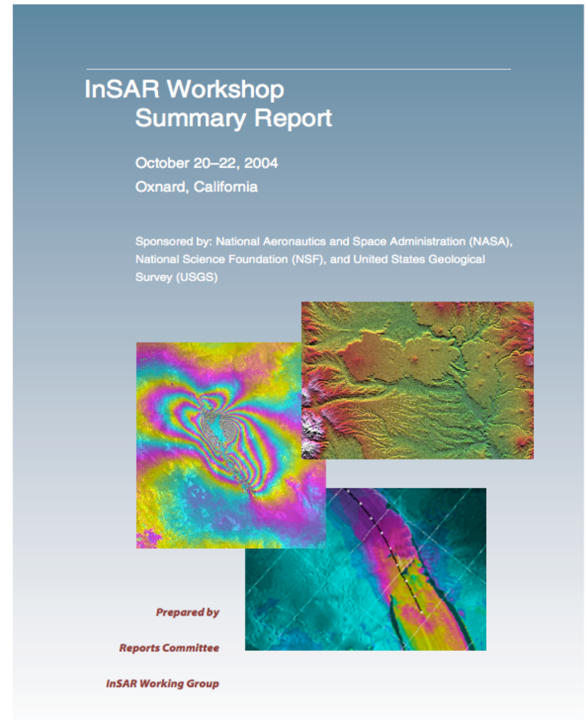
Highest priority of NASA's Solid Earth Science Working Group

Supported in NRC Review

Recommended for the Global Earthquake Satellite System



Department of Defense Applications



Howard Zebker (Chair) Stanford
Involvement:
NASA, NSF, USGS, Universities (63)

Engaging hundreds of scientists and user communities in multiple disciplines

Decadal Survey

Decadal Survey Mission	Mission Description	Instrument
Timeframe 2010 – 2013		
DESDynI	Surface and ice sheet deformation for understanding natural hazards and climate; vegetation structure for ecosystem health	L-band InSAR Laser altimeter

NASA is looking for a funding wedge to implement recommendations

International Partners

- Talking to Japan, Europe, Brazil, Taiwan
- Look for constellation of satellites
- Coordinate independent missions

CEOS

- Committee on Earth Observing Satellites
- Coordinate with GEOSS
- Implementation side of GEOSS?

Ground Segments

- ISIS: International SAR Information Service
  - Exists in concept, but no formalization
  - GGOS could be an important advocate
- Need to set data policies
- Acquisition and processing should be coordinated

International Years

- IPY: International Polar Year
  - Serves as a focus for activities
- International Year of Planet Earth
- International Heliophysical Year
- International Electronic Geophysical Year
  - Informatics

Geodetic Networks

- Support InSAR
- Provide geodetic control
- Provide tropospheric maps
- Calibrate/validate InSAR
- Complement InSAR observations
  - Temporal continuity

Complementary Measurements

Crustal deformation

- Earthscope Plate Boundary Observatory, SCIGN, and International GPS measurements
  - Provide detailed deformation time history of points within an image
  - Provide [sparse] constraints on troposphere and ionosphere
- GRACE Gravity field provides estimates of large scale mass changes that would be a component of a topographic change signature

Cryospheric science

- ICESAT Lidar altimetry provides changes in ice thickness that complement ice velocity measurements in mass balance equation
- GRACE Gravity field provides constraints on ice mass changes
- GPS In situ measurements of ice velocity for calibration and verification

Hydrology and Soil Moisture

- GRACE Gravity field provides estimates of large scale groundwater variability

Land Cover and Land-Cover Change

- Lidar vegetation recovery mission provides detailed vertical profiles of canopy structure that serve as reference for radar-polarimetrically derived vegetation canopy stock and change
  - Provides complementary measurement of canopy height and structure
  - Synergistic measurements are most effective (separate platforms)

Oceanography

- Advanced altimetry for high resolution coastal bathymetry and currents provides complementary information to high-resolution surface winds and coastal change imagery

InSAR Studies Underway

JPL

Examine the trade space for augmenting an InSAR mission to address additional science disciplines

Crustal Deformation, Cryosphere and Climate — ***Core InSAR Science***

Terrestrial Carbon Cycle

Soil Moisture and Hydrology

Ocean Salinity (as an Aquarius follow-on)

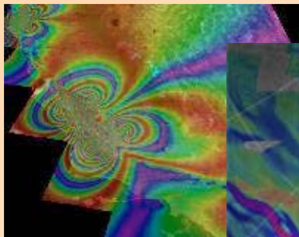
Other science that has been studied with Radar and Radiometry

Study Process

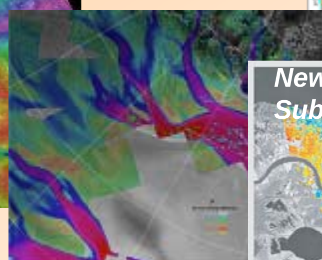
- Adopt science requirements for each science area
- Perform instrument technology trades with NASA investments in mind
- Estimate implementation feasibility

Science Measurements

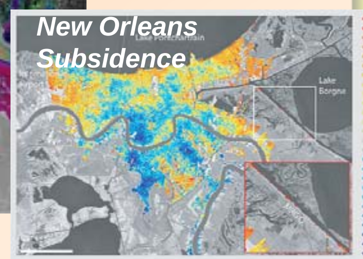
At L-band, measure 3D surface deformation in global deforming regions with an intrinsic frequency of 8 days



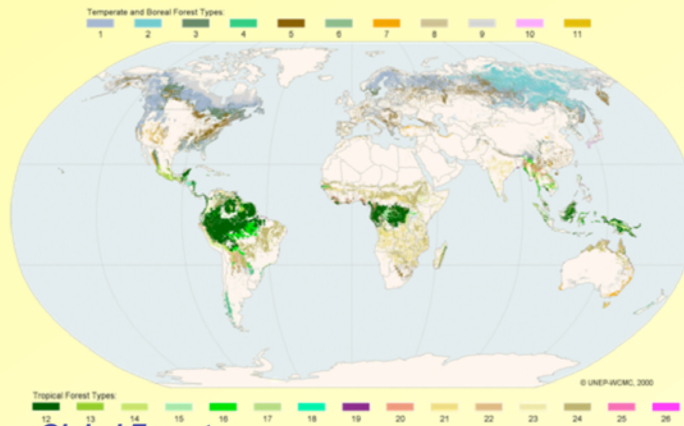
Crustal Deformation



Cryosphere Climate

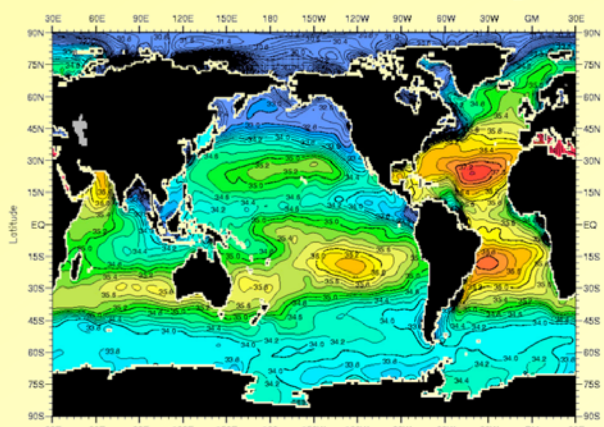


Measure the biomass extent, variability, and structure from L-/P-Band Quad-Pol measurements



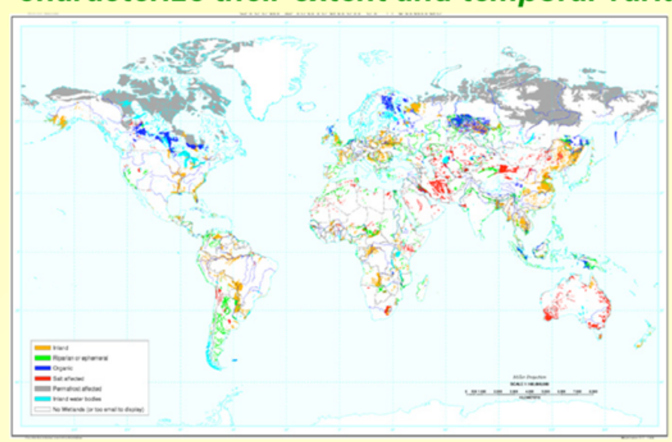
Global Forests

Measure sea surface salinity with passive radiometry, with L-Band scatterometer surface roughness correction



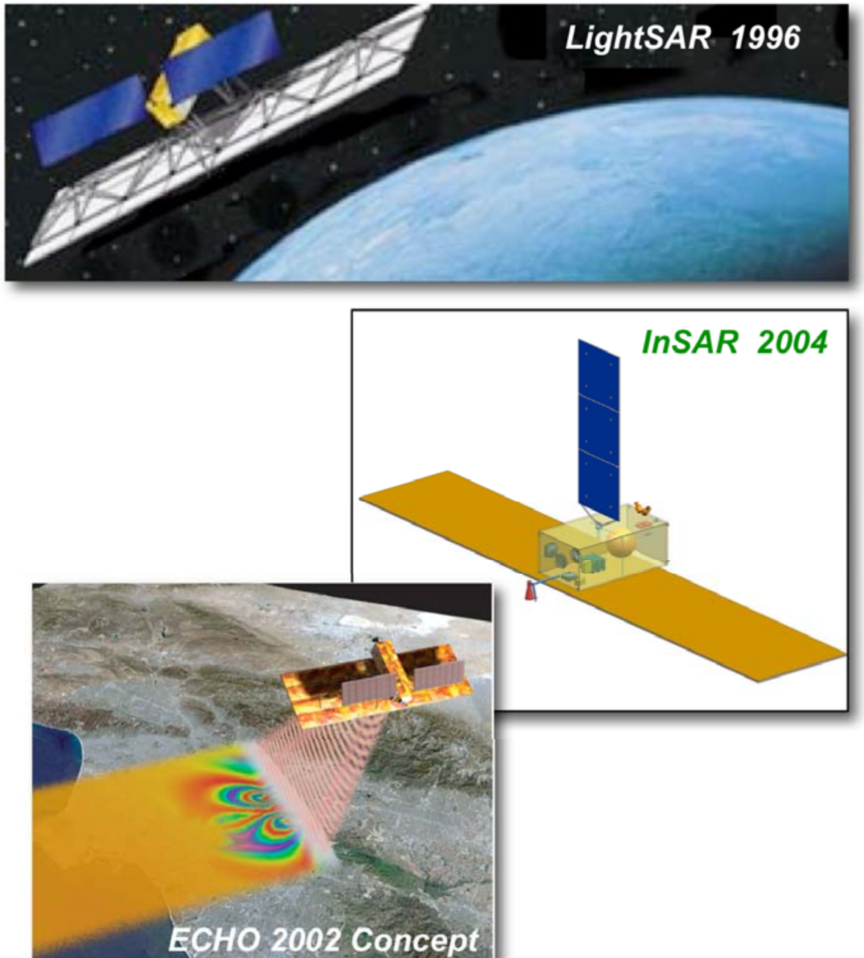
Global Sea Surface Salinity

Measure polarimetric signature of wetlands to characterize their extent and temporal variability



Global Wetlands

Previously Proposed InSAR Concepts



Phased Array Advantages

- Straightforward radar beam-forming and control
- High thermal dissipation balanced by large radiating area
- Graceful degradation

Phased Array Disadvantages

- Current technology and materials drive a high mass density on a large array
- Large number of elements drive to higher integration costs
- **<u>Accommodation of multiple frequencies drives design to larger and/or more complex aperture</u>**

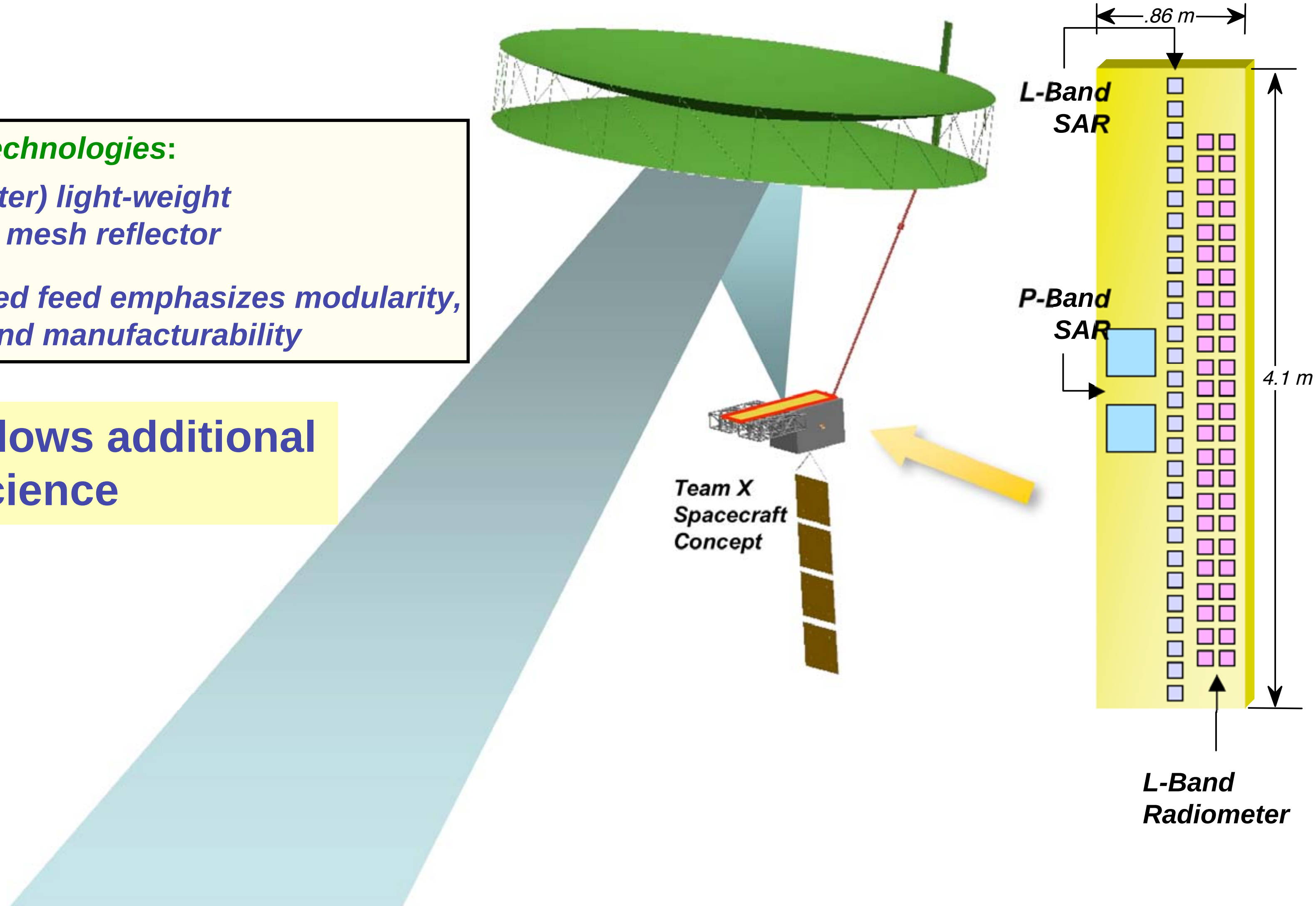
Meeting additional science requirements drove the decision to consider a different radar implementation in subsequent trades

InSAR Solution for Additional Science

***Enabling Technologies*:**

- ***15m (diameter) light-weight deployable mesh reflector***
- ***Small, shared feed emphasizes modularity, efficiency and manufacturability***

Allows additional Science



InSAR Trades for Additional Science

Principal InSAR Mission Trade space

Mission Options	Science Capability: Crust Climate	Terr Carbon	Hydro. Science	Ocean Science	Description
Reference Mission: L-Band Quad-Pol	Designed	Contributes		Contributes	Phased Array option, elevation steering Core InSAR + moderate vegetation, and ocean waves
Option 1: L-Band Single-Pol	Designed			Contributes	Reflector option, elevation beams Core InSAR
Option 2: L-Band Quad-Pol	Designed	Contributes		Contributes	Reflector option, elevation beams Core InSAR + moderate vegetation, and ocean waves
Option 3: L-/P-Band Quad-pol	Designed	Designed	Contributes	Contributes	Reflector option, elevation beams Core InSAR + heavy vegetation, + regional soil moisture
Option 4: L-/P-Band Quad-pol + L-Band Rad/Scatt.	Designed	Designed	Designed	Designed	Reflector option, elevation beams Core InSAR + heavy vegetation, + regional soil moisture + Aquarius follow -on salinity
Option 1a - 4a:	Add water vapor instrument to enhance sensitivity of crustal deformation / climate measurements (see full package for details)				

Designed to Address Science Objective
Contributes to Science Objective

Reflector Options

Study Summary

- InSAR mission at L-band can be implemented with either phased array or feed-reflector technology
  - Both technologies are mature and feasible
- Additional science can be accommodated in feed-reflector implementation with straightforward instrument augmentations
  - Additional feeds are relatively small, mounted on the spacecraft
  - Electronics components are modular and mature
- Important factors in optimizing total science mission are
  - Orbit reconfiguration (e.g. 8-day repeat vs. 30-day repeat)
  - Baseline (e.g. zero for deformation vs. multiple for vegetation)
  - Mode contention (e.g. ScanSAR vs. Quad-pol)
  - Data rate and volume for multiple simultaneous modes