Sources for Science Objectives

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

Engaging hundreds of scientists and user communities in multiple disciplines

...as captured in the NASA Science Plan
## Decadal Survey

<table>
<thead>
<tr>
<th>Decadal Survey Mission</th>
<th>Mission Description</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESDynI</td>
<td>Surface and ice sheet deformation for understanding natural hazards and climate; vegetation structure for ecosystem health</td>
<td>L-band InSAR Laser altimeter</td>
</tr>
</tbody>
</table>

**Timeframe 2010 – 2013**

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

**Crustal Deformation, Cryosphere and Climate**
- Terrestrial Carbon Cycle
- Soil Moisture and Hydrology
- Ocean Salinity (as an Aquarius follow-on)

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

Global Sea Surface Salinity

New Orleans Subsidence

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

Global Wetlands

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.

Freshwater Withdrawal
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
• Accommodation of multiple frequencies drives design to larger and/or more complex aperture

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

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

- **Red** indicates Designed to Address Science Objective
- **Pink** indicates Contributes to Science Objective
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