Surface Topography and Vegetation Study

Airborne Planning

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Needed measurement or observation

- STV surrogate data
  - Separate vegetation from bare Earth topography
  - For development of data fusion algorithms
  - Over a variety of targets and configurations

- Observation types
  - Radar
    - vegetation density
  - Lidar
    - vertical profile
    - canopy height
  - Stereomaging
    - Color
    - Wide field of view
Measurement requirements

• Contemporaneous radar, lidar, stereoimaging
  • Ideally within 1 hour (≤3 days) airborne
  • ≤3 days with satellite

• Measurement
  • Ideally ≤3m 3D

• Coverage
  • Multiple STV discipline targets
  • Consideration of ICESat-2, GEDI, optical orbits and timing

• Availability of Ground Truth Measurements
  • Contemporaneous UAV and ground measurements
Payload/instruments

• TBD at time of campaign but likely
  • UAVSAR/AirSAR
    • SAR-Fusion? (SWIR/Vis)
  • LVIS/CASALS
  • QUAKES

• Contemporaneous satellite-based observations such as
  • High Resolution stereoimagery (David Shean)
  • High Resolution Bistatic Radar (Pietro Milillo)
  • Laser Altimetry (Brooke Medley)
Where, when, and how the measurement needs to be made

• Prefer similar airspeeds – 900 km/hr
  • Dependent on contemporaneous requirements

• Nominal altitude 12.5 km TBD by team
  • UAVSAR – 12.5 km
  • LVIS – from website, 10 km is typical
  • QUAKEs – 12.5 km

• Match swath widths of sensors
  • UAVSAR – 16 km
  • LVIS – from website, 2 km is typical
  • QUAKEs – 12 km at 12.5 km altitude

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STV Proposed Airborne Campaigns

Year 1: East coast
- Summer
- Repeat Harvard forest in winter (leaf off)

Year 2: West Coast
- Time of year TBD

Year 3: Pacific
- Time of year flexible, but should avoid rainy season

Optional ABOVE site
- Well-characterized
- Not near other targets of interest
Sample Challenges to Address through Campaigns

To be fleshed out by STV science and technology groups and airborne planning group

- Temperate forests
  - Ability to resolve ground in summer
  - Establish need for leaf off observations

- Boreal forests
  - Ability to resolve ground based on vegetation density
  - Ability to resolve tree height when crown narrows below resolution
    - Assess need for calibration

- Steep Slopes
  - Extent of minimizing shadows required (sun elevation)

- Snow and Ice
  - Extent roughness and shadowing improves topographic estimates
  - Assess variable penetration for different measurement approaches

- Shallow water
  - How much turbidity affects ability to resolve bottom

- Temporal changes
  - How close in time are measurements from different instruments needed?
    - e.g. flow or leaves blowing

- Tropical forests
  - Existing data for now?
  - Take advantage of existing campaigns and complement with additional instrument type
Intercomparison

- Measurements between technologies won’t agree
- Measured surface is likely different between each technique
- What are the return horizons?
- Drives need for contemporaneous observations
- Scale of intercomparison
  - How to calibrate between measurements (hectare, few meters?)
- Fusion aspect
  - How to maximize the strengths of each method
- Need in situ and calibration/validation measurements
General Study Sites

- East Coast
- West Coast
- Pacific (Hawaii)

Study Team Tasks
- Identify existing field data collection sites
- Ensure regions are easy to access and friendly to US overflight requests
- Identify spacecraft overflight tracks of different techniques

<table>
<thead>
<tr>
<th>STV Airborne Site Characteristics</th>
<th>West Coast</th>
<th>Pacific</th>
<th>East Coast</th>
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<tbody>
<tr>
<td><strong>Forest</strong></td>
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<tr>
<td>Temperate Forest</td>
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<tr>
<td>Tropical</td>
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<td>Boreal Forest</td>
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<td>Wetland</td>
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<td>Mangrove</td>
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<td>Leaf on, Leaf off (seasonal changes)</td>
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<td><strong>Solid Earth</strong></td>
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<td>Volcanoes</td>
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<td>Steep slopes/gradients</td>
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<td><strong>Hydrology &amp; Coastal</strong></td>
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<td>Emerging Vegetation (wetlands)</td>
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<td>Lakes</td>
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<td>Bottom types</td>
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<td>Snow on, Snow off</td>
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<td>Sea ice</td>
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Flight Hours and Cost Estimate

• Assumption
  • One Gulfstream on east and west coast
  • 42 flight hours per year total
  • 26 – 27 hours of transit for each campaign (should collect opportunistic data where possible)
  • ~$500K

• 15 hours per experiment per year (~13,000 km)

• Data processing costs approximating same as campaign
  • ~$500K split between radar, lidar, stereoimaging
Platforms

• UAVSAR – dedicated Gulfstream-3 (AFRC)
• QUAKES and LVIS
  • Shared Gulfstream-3 (Langley)
Summary

• Collect contemporaneous lidar, radar, and stereoimaging data
  • Provide surrogate data for space-based performance modeling and science
  • Use NASA Gulfstream aircraft for consistent airspeeds
  • Oversample and compare to simulated orbit track data

• Focus on different types of targets
  • Temperate (leaf on and off) forests, boreal forests, wetlands
  • Bare and vegetated surfaces
  • Steep and shallow surfaces
  • Snow, ice, and permafrost

• Create airborne campaign planning group
• Ensure ground/near-surface calibration/validation data
• ~15 hours/year per region not including transit
• Expect equal resources for flight time and data processing