Surface Topography and Vegetation Study

Airborne Planning

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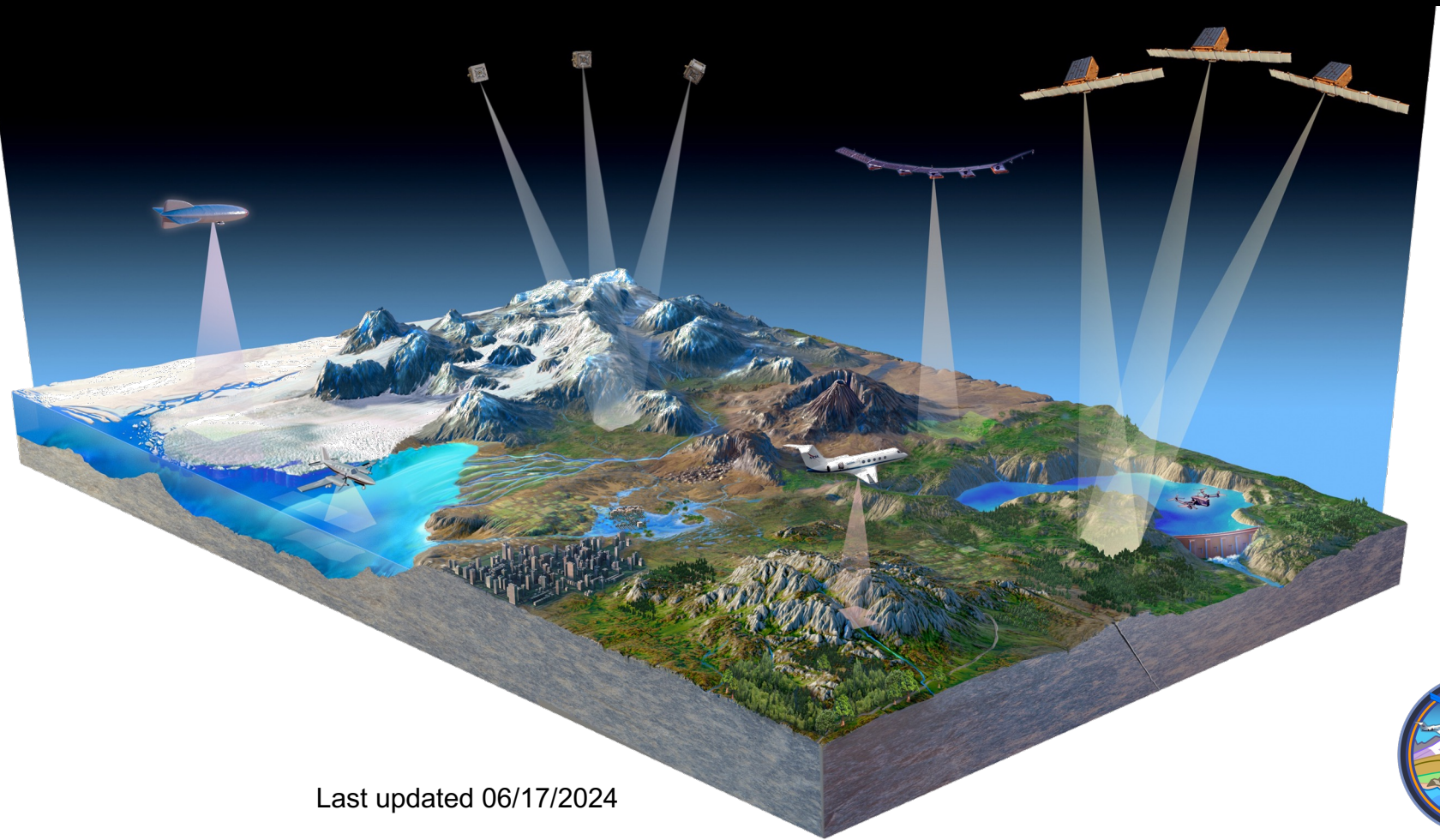

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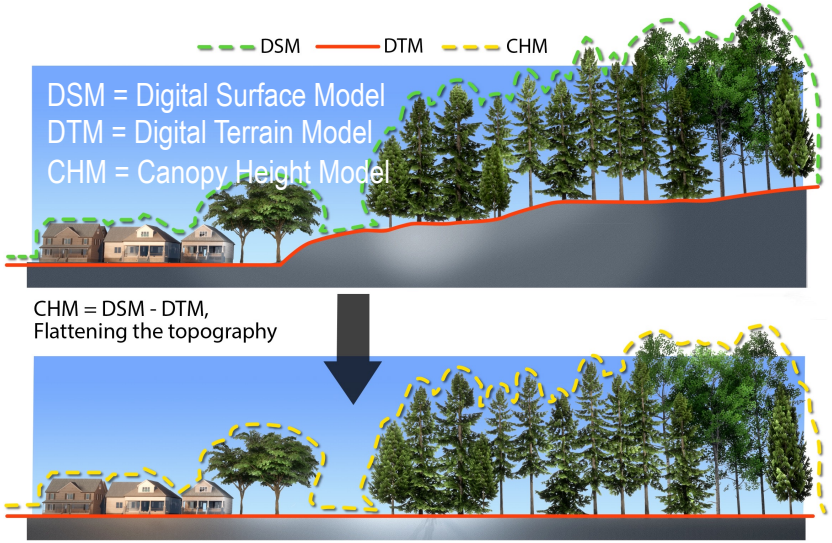
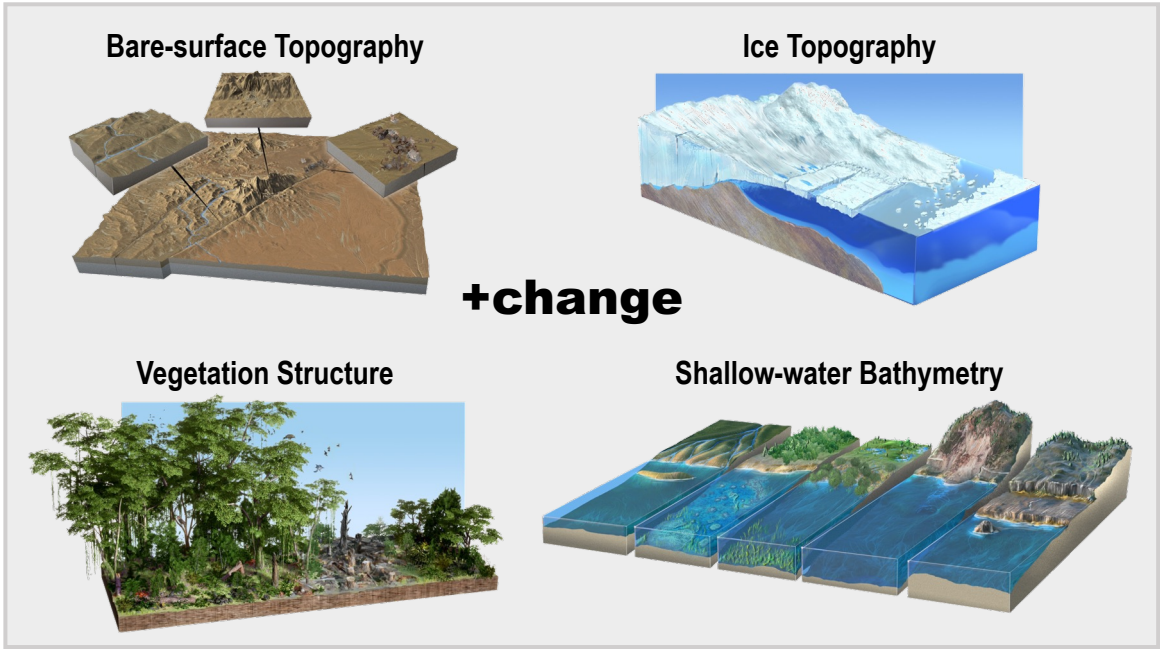
Needed measurement or observation

- 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
  - Stereoimaging
    - Color
    - Wide field of view





Measurement requirements

- Contemporaneous radar, lidar, stereoimaging
  - Ideally within 1 hour (≤3 days) airborne
  - ≤3days 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

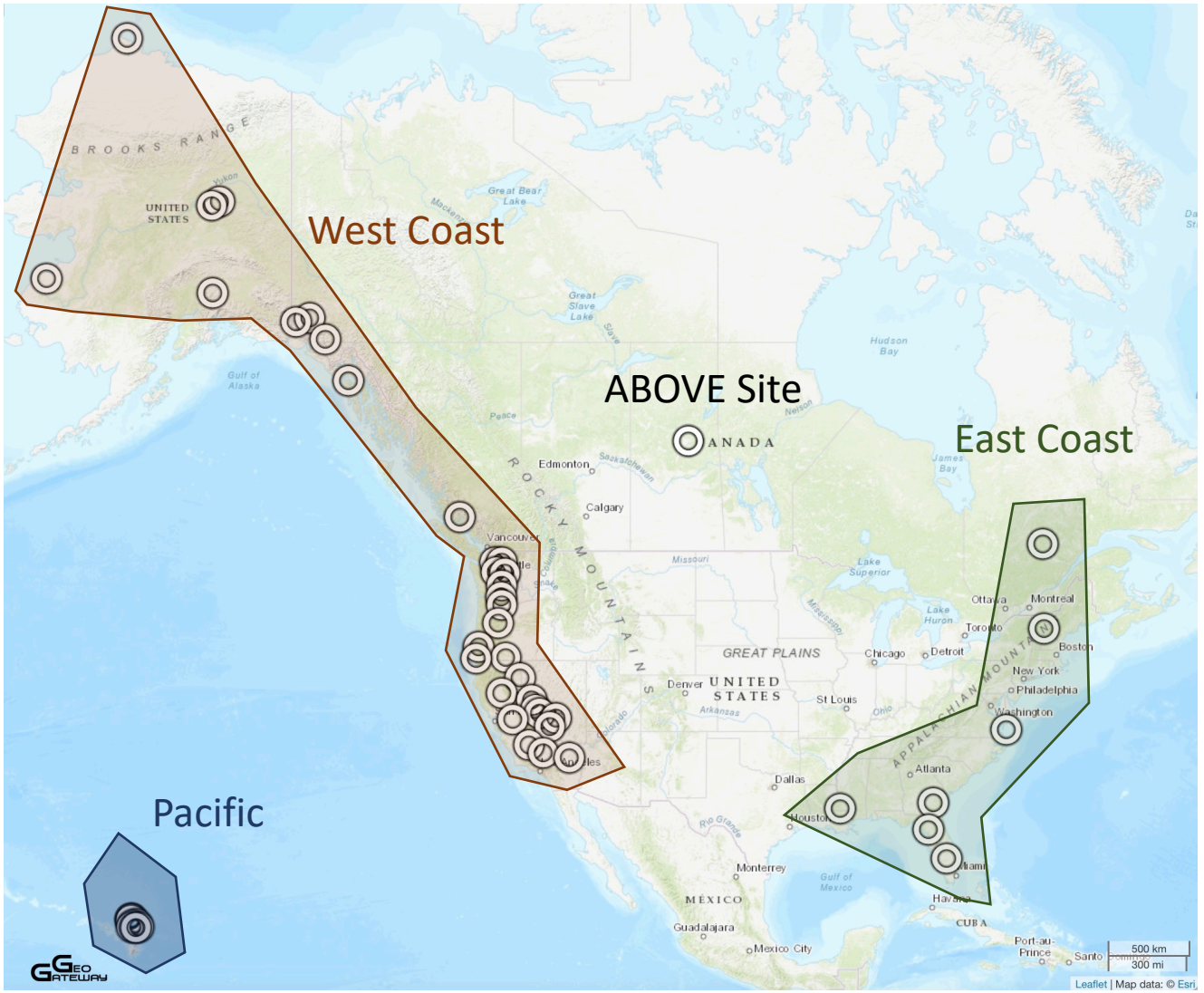
STV Proposed Airborne Campaigns

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



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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

STV Airborne Site Characteristics			
	West Coast	Pacific	East Coast
Forest			
Temperate Forest	x		x
Tropical		x	
Boreal Forest	x		x
Wetland	x	x	x
Mangrove			x
Leaf on, Leaf off (seasonal changes)	x		x
Solid Earth			
Volanoes	x	x	
Landslides	x		x
Tectonics	x	x	
Steep slopes/gradients	x	x	x
Surface roughness	x	x	x
Hydrology & Coastal			
Emerging Vegetation (wetlands)	x	x	x
Lakes	x		x
River	x		x
Turbidity	x	x	x
Ocean	x	x	x
Rigosity/Roughness	x	x	x
Bottom types	x	x	x
Snow on, Snow off	x		x
Cryosphere			
Permafrost	x		
Glaciers	x		
Sea ice	x		x

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