Surface Topography and Vegetation (STV) Incubation Study

Introduction and Study Overview

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Ground Rules

- Only material suitable for full and open distribution shall be submitted
  - Submittals shall be considered approved by the providing organization to be suitable for full and open distribution
  - No proprietary, export controlled, classified, or sensitive material should be provided

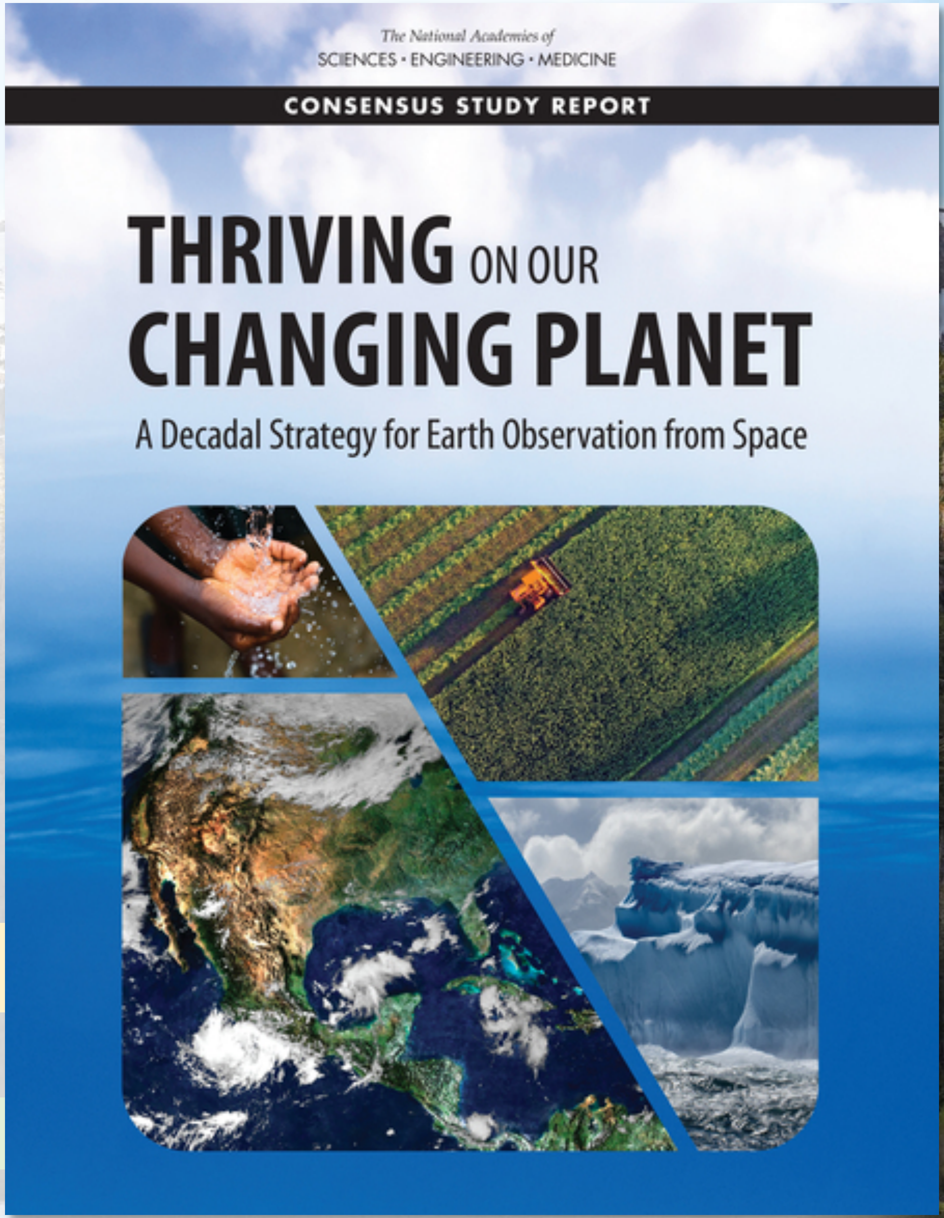
- **Q&A:** https://arc.cnf.io/sessions/qkrg/#!/dashboard

Decadal Survey

- Targeted Observable:
  Surface Topography and Vegetation
- *High-resolution global topography*, including bare surface land topography, ice topography, vegetation structure, and shallow water bathymetry
- Candidate Measurement Approach: radar or lidar *[Stereo Photogrammetry]*

Solid Earth ***Ecosystems*** ***Climate*** ***Hydrology*** ***Weather***

Solid Earth ***Vegetation Structure*** ***Cryosphere*** ***Hydrology*** ***Coastal Processes***

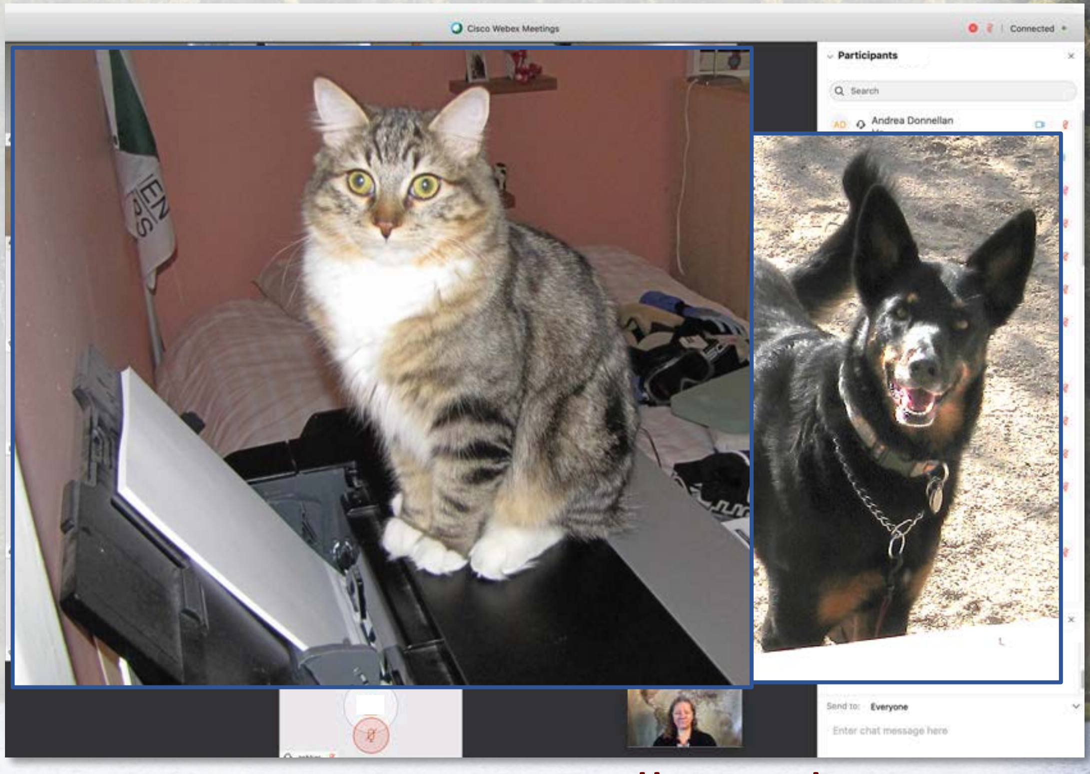


https://www.nap.edu/catalog/24938/thriving-on-our-changing-planet-a-decadal-strategy-for-earth

Decadal Survey Incubation

- **Solicitation A.54 "Decadal Survey Incubation Study Team:** Planetary Boundary Layer and **Surface Topography and Vegetation"**
- Selected team began work in March 2020
- Team will produce a white paper that will identify science needs and gaps

How we expected to work



How we actually work

Team Members

Lead

Andrea Donnellan

Tech Lead

Dave Harding

Cryosphere

Alex Gardner

Applications

Cathleen Jones

Marco Lavalle

Radar

Yunling Lou

Solid Earth

Paul Lundgren

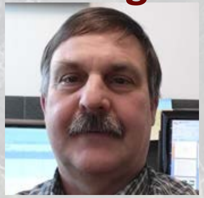
Scott Luthcke

Batuhan Osmanoglu

Coastal Processes

Christopher Parrish

Stereo Photogrammetry



Jon Ranson

Sassan Saatchi

Hydrology

Marc Simard

Lidar

Jason Stoker

Robert Treuhaft

Vegetation Structure

Konrad Wessel

Topography Needs Identified in Decadal Survey

- **Earthquakes, volcanoes, land surface:** Characterize using high-resolution bare Earth topography
- **Ecosystems and carbon cycle:** evapotranspiration and gross primary productivity spatially variable with topography
- **Surface biology and geology:** rugged topography and changing landscapes
- **Relationships between climate, tectonics, and topography**
- **Ice sheets:** topography of ice and land
- **Mountain hydrology:** understand spatially varying topography, snow accumulation and melt
- **Soil moisture:** variations in topography drive recharge and evaporation
- **Coastal vertical motion:** global topography is needed to predict the path and magnitude of inundation across subsiding areas and during large storms
- **Disaster Response:** high-resolution topography, landslides, flooding, volcanoes, earthquakes, tsunami run-up
- **Energy, mineral, and soil resources:** Map topography to improve discovery and management

STV Incubation

- **STV incubation:** seeks observing system architectures utilizing emerging sensors that will allow for the development of **contiguous**, **high-resolution, bare-surface land topography, ice topography, vegetation structure, and bathymetry** data products with ***global coverage and seasonal interannual repeat*** cycles.
- **Decadal Survey:** "topographic mapping from space on a **contiguous and high-resolution grid** poses a major technological challenge, it is a necessary and logical next step that promises to transform understanding of landscape evolution and the interactions of processes that shape them. ….. ***Space-based, global coverage remains an important but unrealized goal at present***."

STV Targeted Observable

Team deliverables (in the form of a white paper building on the decadal survey)

- Science and applications objectives, including forward-looking spatial, temporal, and spectral capabilities
- Measurement characteristics, including capabilities now available or in development for suborbital and space-based approaches
- A preliminary Science and Applications Traceability Matrix (SATM)
- Example approaches and activities for advancing maturity such as modeling, OSSEs, field campaigns, enhanced analysis of existing data, and instrument or lab work, which could inform a range of future observing system architectures utilizing emerging sensor and information technologies
- Characterized efforts critical to maturing spaceborne components towards flight on a 10-year incubation timescale
- Potential roles of spaceborne, airborne, and surface-based components
- Potential commercial approaches, including the use of commercial data
- Existing efforts that could contribute to advancing maturity on a 10-year timescale

We need community input!

Relation to other Missions and Opportunities

- Observing system components that could be ready to compete for Venture-class opportunities within a five-year timescale
- Potential synergies with the decadal survey Designated and/or Earth System Explorer TOs and Program of Record
- Determination of the potential to leverage Ice, Cloud and land Elevation Satellite-2 (ICESat-2), Global Ecosystem Dynamics Investigation (GEDI), Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), Aeolus, and/or other existing spaceborne lidar data to reduce gaps in existing or planned PBL/STV activities

Objectives

- Develop a Science and Applications Traceability Matrix (SATM) to identify gaps and flow down goals to technology and approaches
- Justify SATM with references, models, simulation, and analysis
- Consider improved lidar, radar, and stereo photogrammetry concepts
- Identify data acquisition or integration strategies to advance STV science

To promote the development of contiguous, high-resolution, bare-surface land topography, ice topography, vegetation structure, and shallow-water bathymetry data products with global coverage and seasonal to interannual repeat cycles

Lidar Radar Stereo Photogrammetry

Science Breakouts

Solid Earth

- Tectonics/deposition/ erosion/climate coupled processes
- Earthquake, volcano and landslide assessment, response, mitigation and modeling
- Anthropogenic and natural change detection

Vegetation Structure

- Ecosystem structure and function
- Carbon accounting
- Biomass inventory, dynamics, monitoring
- Biodiversity, habitat structure and response to disturbance
- Forest resources management
- Wildfire, fuel, risk and post-fire recovery

Cryosphere

- Ice sheet, ice cap and glacier elevation change and sea level impact
- Sea ice thickness and cover change and impact on the ocean/atmosphere system
- Ice flow and dynamics
- Constraints for time-series modeling

Hydrology

- Lake and reservoir heights and shallow bathymetry
- Snow depth and melt impact on water resources
- Stream and river flow
- Flooding and inundation modeling
- Wetland processes and management

Coastal Processes

- Storm surge and tsunami inundation hazards
- Shoreline erosion and sediment transport
- Benthic habitat and marine ecosystems
- Tidal interaction with mangroves and salt marshes
- Shallow water navigation and hazards

Applications

Subgroup Leads

Science/Applications

Solid Earth

Paul Lundgren

Ecosystems Structure

Konrad Wessel

Cryosphere

Alex Gardner

Hydrology

Marc Simard

Coastal Processes

Christopher Parrish

Applications

Cathleen Jones

Technology

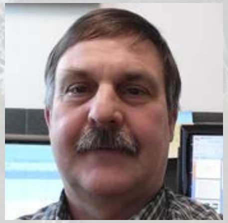
Radar

Yunling Lou

Lidar

Jason Stoker

Stereo Photogrammetry



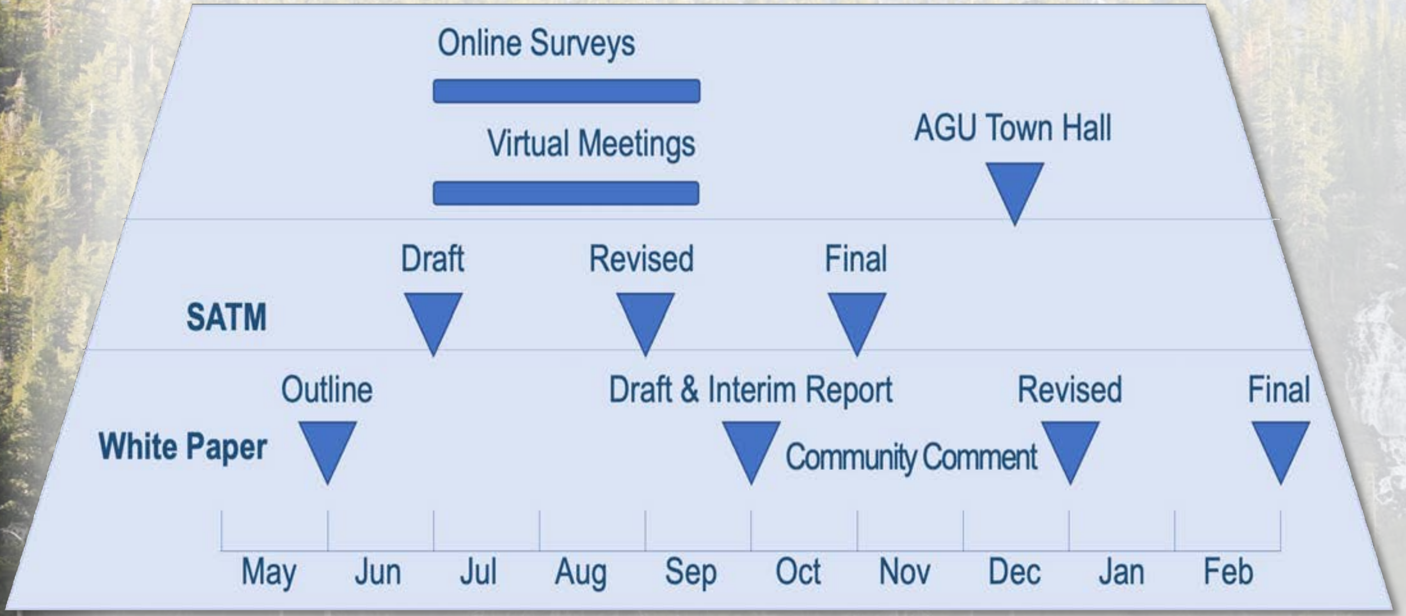
Jon Ranson

Technology Activities

- Identify technology and knowledge gaps that need to be addressed
- Identify focused technology investments, trade space analyses, mission architecture studies and measurement demonstrations that could make substantial advances toward meeting the challenging STV objectives

Schedule

This Study



Next Decade

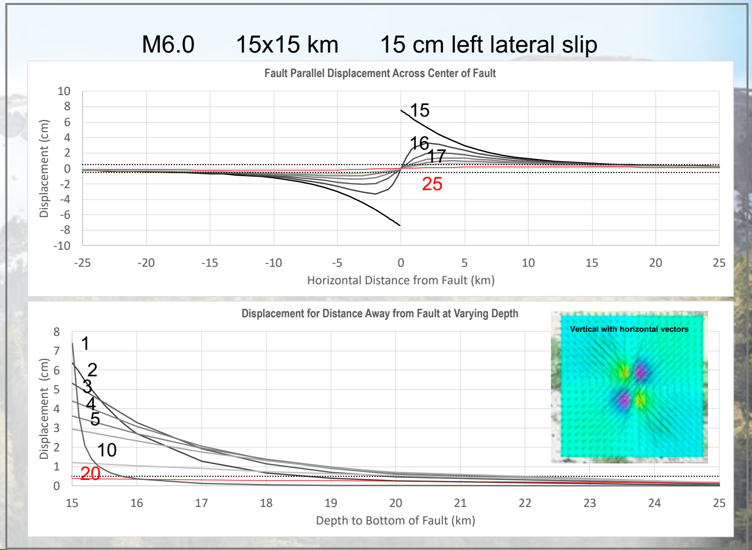
- Incubation studies
- Technology maturation
- Inform next decadal survey (~5 years out)
- Leverage existing data, missions, activities

Contact: stv-leads@jpl.nasa.gov

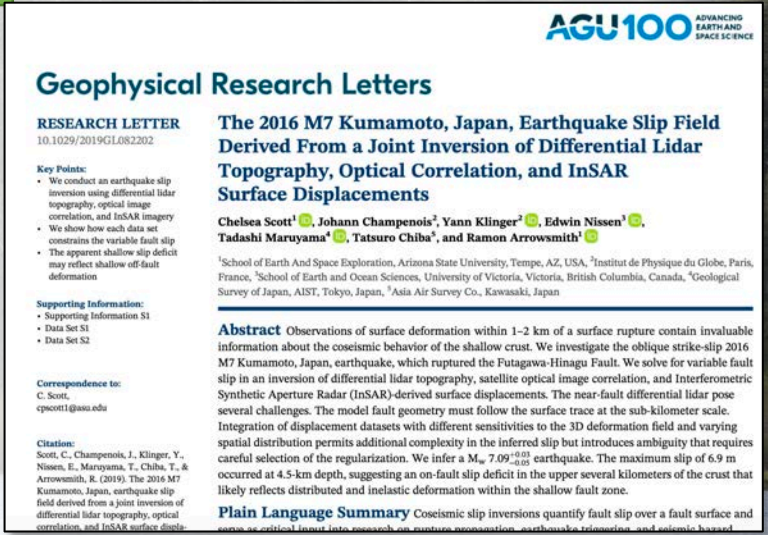
White Paper Outline

i. .... Executive Summary
1. .... Background
2. .... Scope of Study (science and technology)
3. .... Targeted observables
4. .... Science Goals and Objectives
5. .... Current Observational Techniques and Systems
6. .... Science Measurements and Observations
7. .... Gaps and Flow Down
8. .... Needed Investments
9. .... Expected Science and Applications Advances
Appendix A:........ SATM
Appendix B:........ Team Member Contributions
References

Analysis



References



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Geophysical Research Letters

RESEARCH LETTER
10.1029/2019GL082202

Key Points:
- We conduct an earthquake slip inversion using differential lidar topography, optical image correlation, and InSAR imagery
- We show how each data set constrains the variable fault slip
- The apparent shallow slip deficit may reflect shallow off-fault deformation

Supporting Information:
- Supporting Information S1
- Data Set S1
- Data Set S2

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Scott, C., Champenois, J., Klinger, Y., Nissen, E., Maruyama, T., Chiba, T., & Arrowsmith, R. (2019). The 2016 M7 Kumamoto, Japan, earthquake slip field derived from a joint inversion of differential lidar topography, optical correlation, and InSAR surface displa-

The 2016 M7 Kumamoto, Japan, Earthquake Slip Field Derived From a Joint Inversion of Differential Lidar Topography, Optical Correlation, and InSAR Surface Displacements

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Abstract Observations of surface deformation within 1–2 km of a surface rupture contain invaluable information about the coseismic behavior of the shallow crust. We investigate the oblique strike-slip 2016 M7 Kumamoto, Japan, earthquake, which ruptured the Futagawa-Hinagu Fault. We solve for variable fault slip in an inversion of differential lidar topography, satellite optical image correlation, and Interferometric Synthetic Aperture Radar (InSAR)-derived surface displacements. The near-fault differential lidar pose several challenges. The model fault geometry must follow the surface trace at the sub-kilometer scale. Integration of displacement datasets with different sensitivities to the 3D deformation field and varying spatial distribution permits additional complexity in the inferred slip but introduces ambiguity that requires careful selection of the regularization. We infer a $M_w\ 7.09^{+0.03}_{-0.05}$ earthquake. The maximum slip of 6.9 m occurred at 4.5-km depth, suggesting an on-fault slip deficit in the upper several kilometers of the crust that likely reflects distributed and inelastic deformation within the shallow fault zone.

Plain Language Summary Coseismic slip inversions quantify fault slip over a fault surface and

Charge to STV Participants

- Provide your expertise and existing analysis that supports STV
  - Include provenance, citations, references, backup…
- Provide feedback on draft white paper in fall 2020
- SATM will be continued to be filled in through course of incubation study over several years and will provide input to decadal survey
  - Participate in studies and activities
- Keep providing input to our polls
  - https://arc.cnf.io/sessions/qkrg/#!/dashboard