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NGEE Arctic
Next-Generation Ecosystem Experiments

NGEE Arctic LANL Overview

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LANL Institutional Lead
Science Question 5 Co-Lead

March 3, 2022

Next-Generation Ecosystem Experiments: Arctic
Ecosystem Processes
Modeling, Prediction
Systems Understanding

U.S. DEPARTMENT OF ENERGY | Office of Science

OAK RIDGE National Laboratory

Los Alamos NATIONAL LABORATORY

BERKELEY LAB

Brookhaven National Laboratory

UAF UNIVERSITY OF ALASKA FAIRBANKS

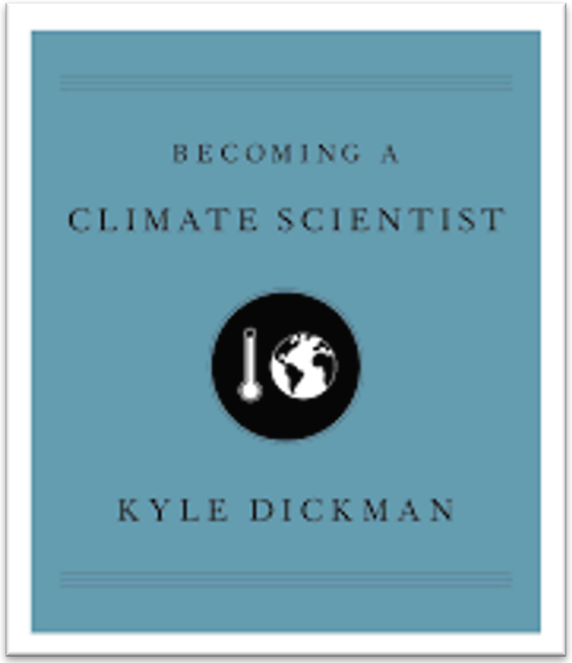
NGEE Arctic (2012-Present)

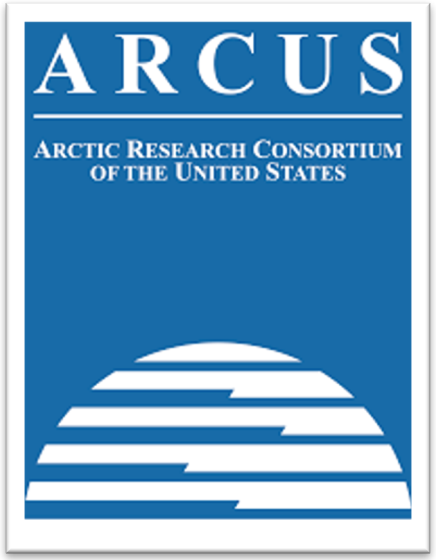
Deliver a process-rich ecosystem model, extending from bedrock to the top of the vegetative canopy/atmospheric interface, in which the evolution of Arctic ecosystems in a changing climate can be modeled at the scale of a high-resolution Earth System Model (ESM) grid cell.

Society and Broader Scientific Involvement

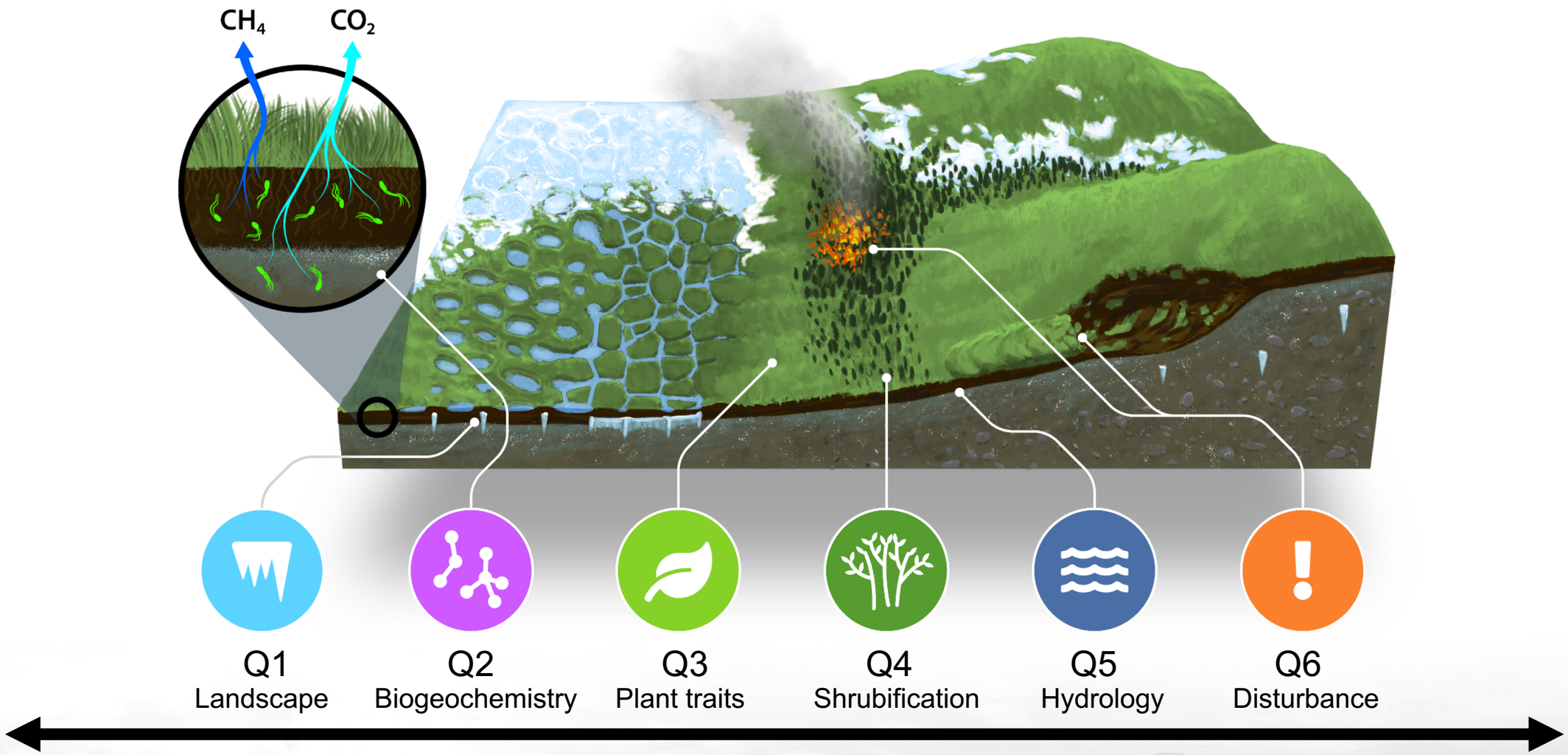
US Permafrost Association

Cathy Wilson: USPA President
Bob Bolton: USPA Co-Chair, DEI Members DEI Committee
Christian Andresen, Julian Dann, Mara Nutt, and Shannon Dillard





NGEE Arctic Phase 3 (2020-2024)



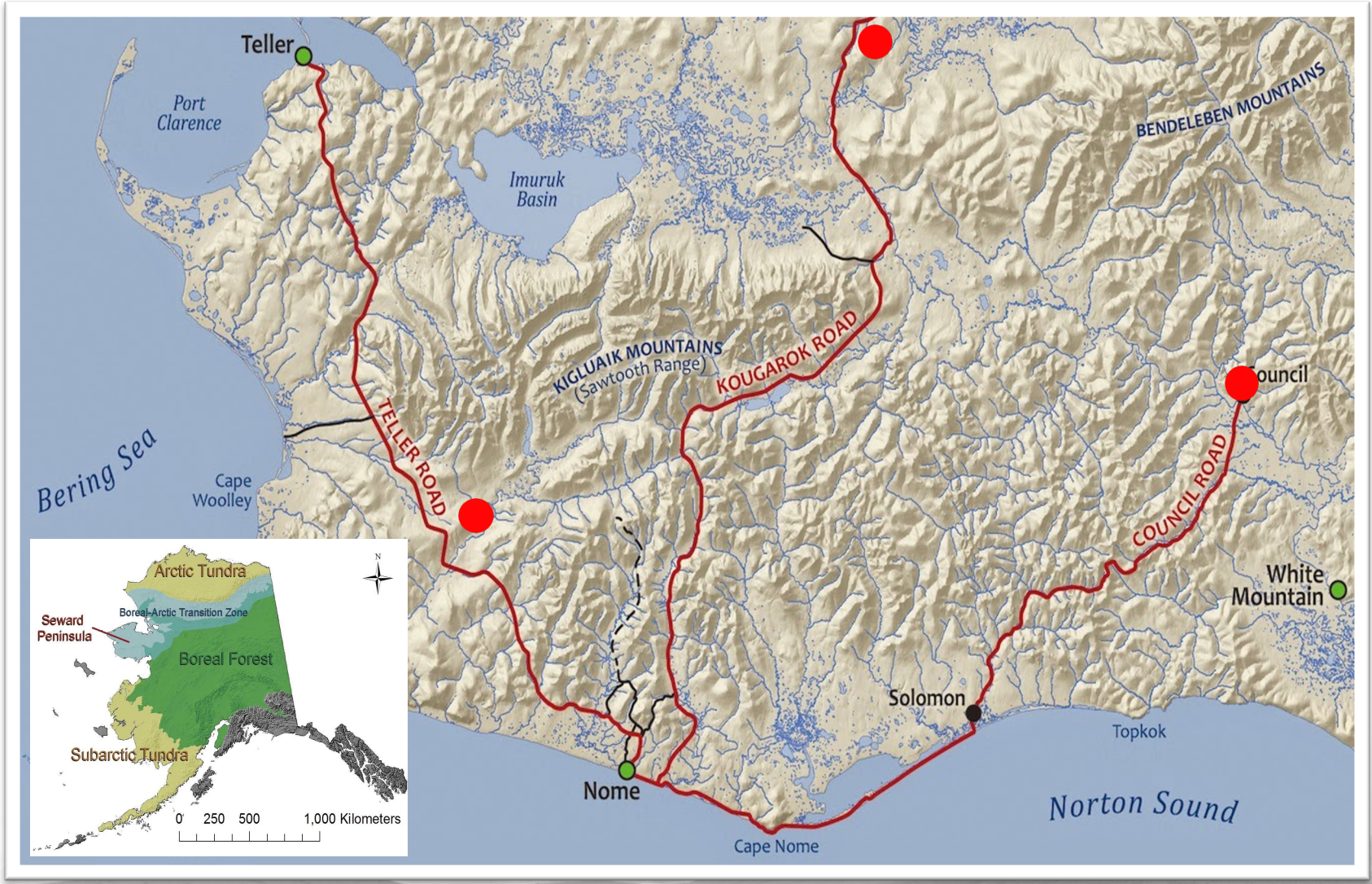
LANL works across multiple NGEE Arctic science questions:

Q1. How does the structure and organization of the landscape control permafrost evolution and associated carbon and nutrient fluxes in a changing climate?

Q5. Where, when, and why will the Arctic become wetter or drier, and what are the implications for climate forcing? (LANL co-lead)

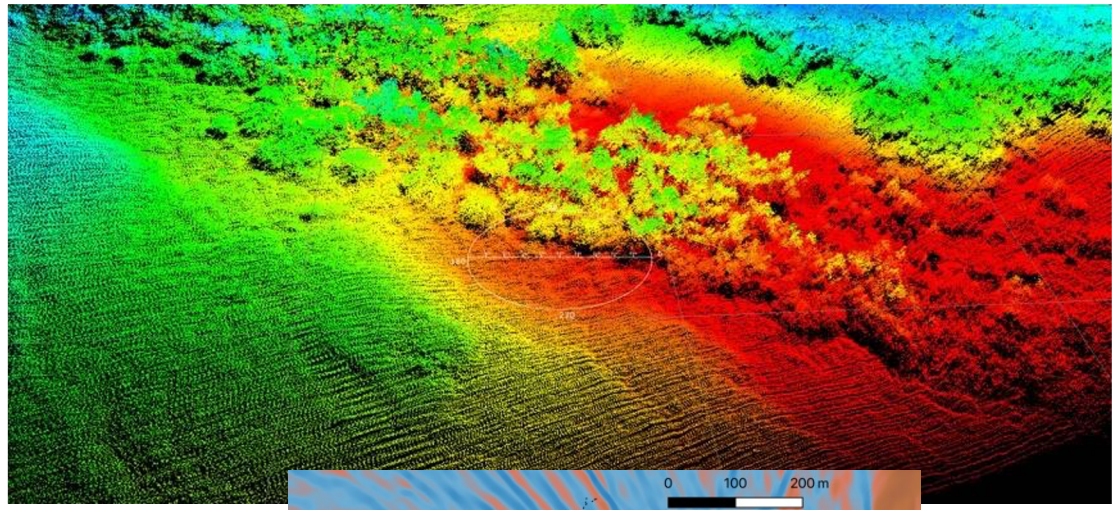
Q6. What controls the vulnerability of Arctic ecosystems to disturbance, and how do disturbances alter the structure and function of these ecosystems? (LANL co-lead)

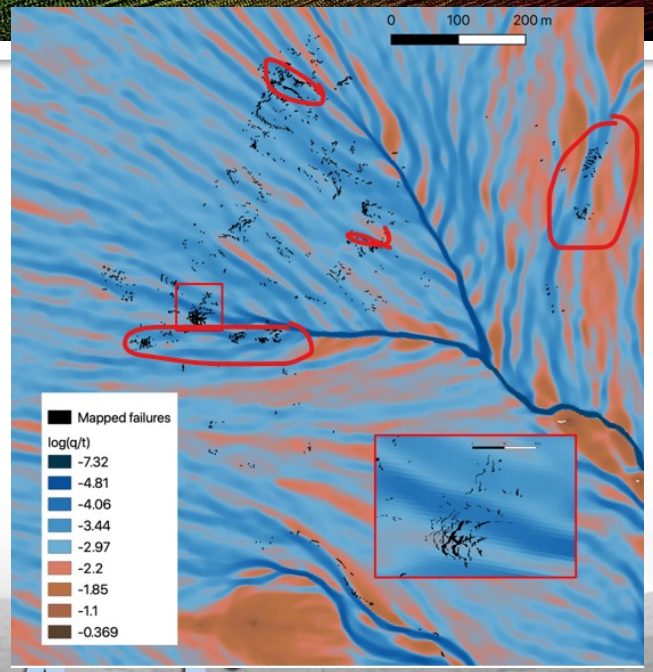
NGEE Arctic Field Sites (Seward Peninsula)

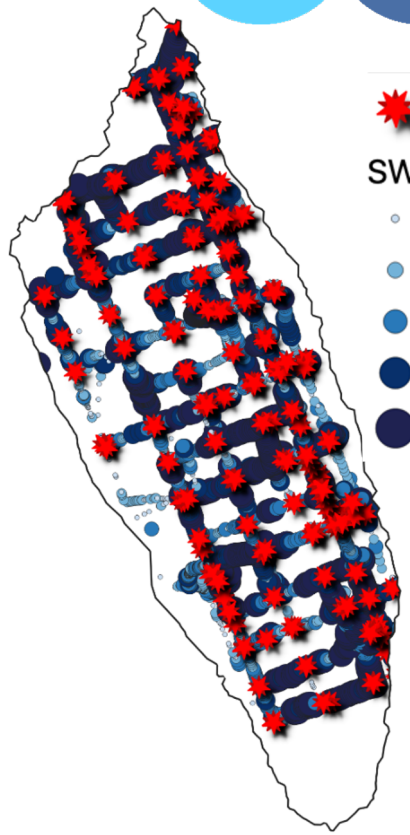


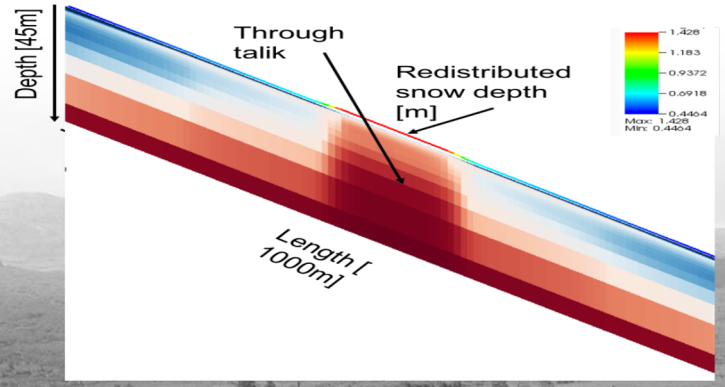
NGEE Arctic
Next-Generation Ecosystem Experiments

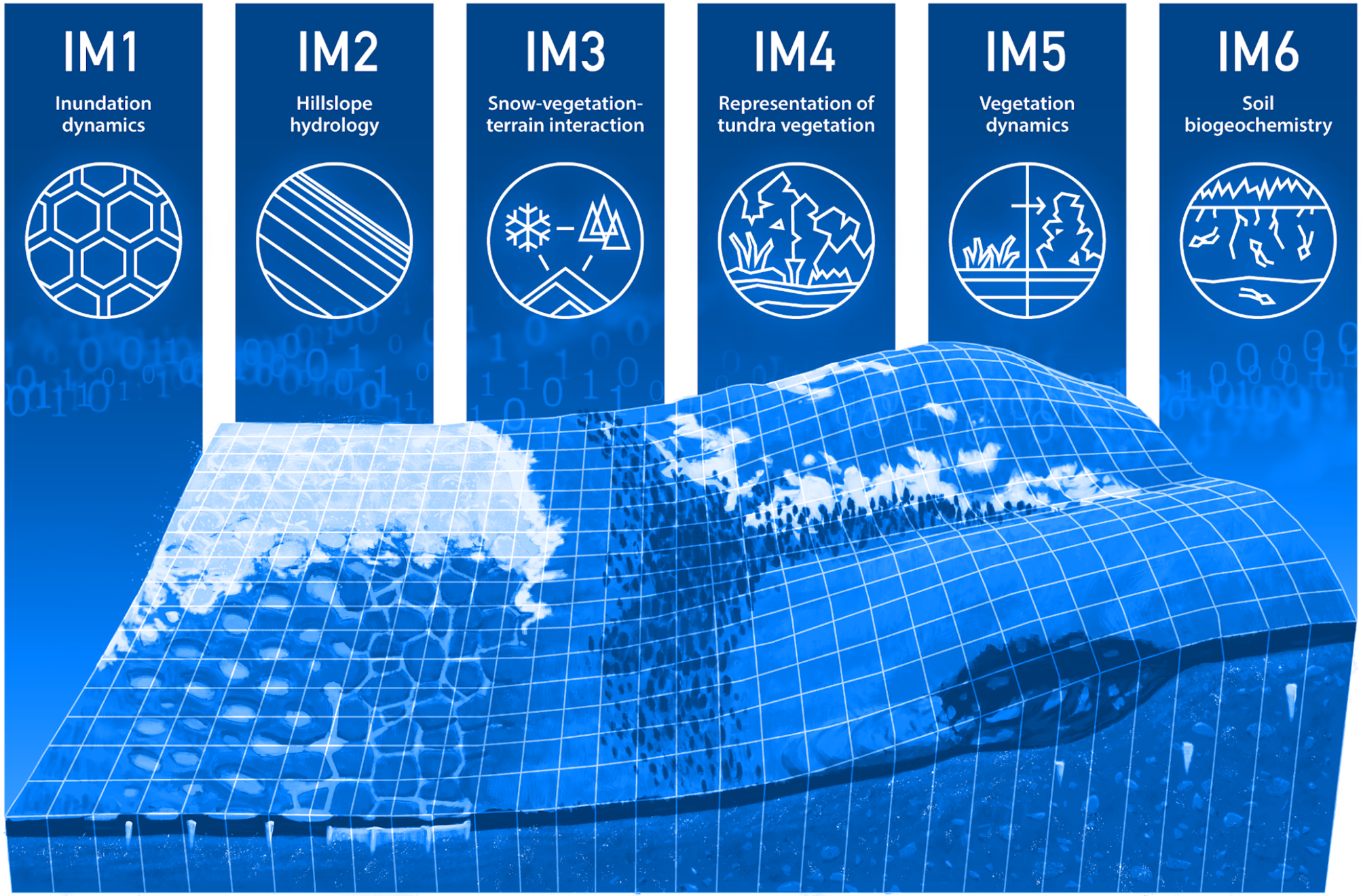
LANL Research Summary Q1, Q5, Q6



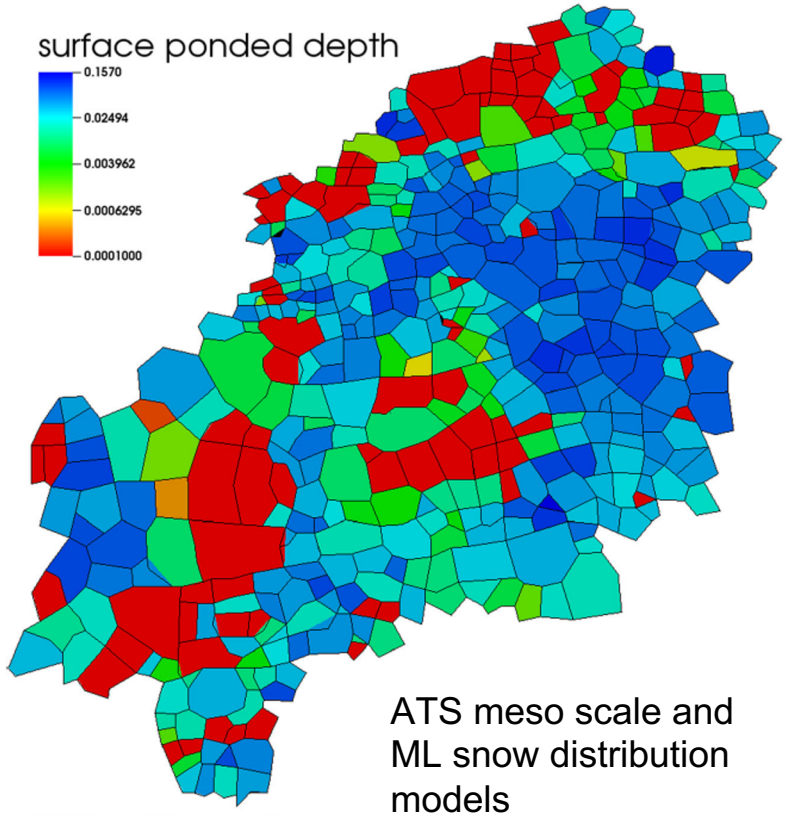




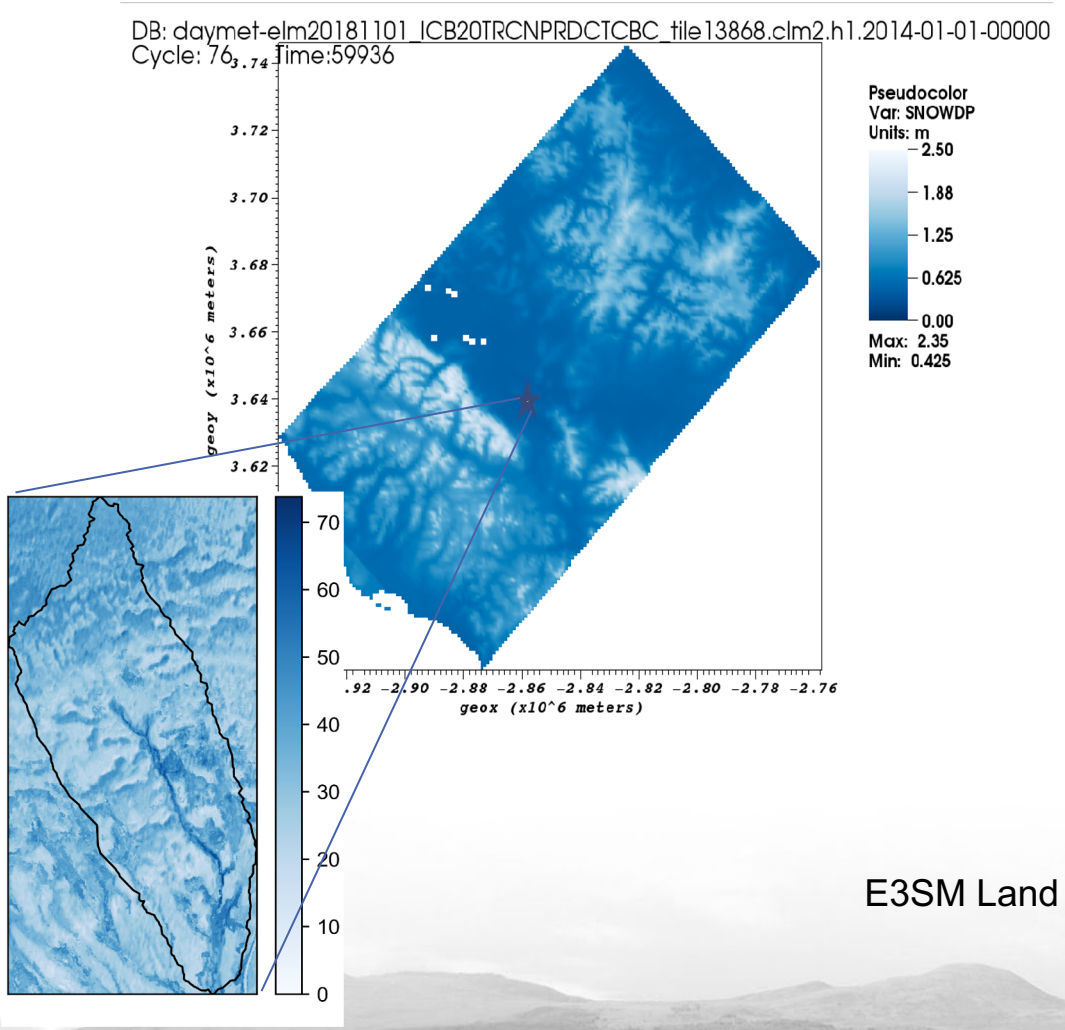


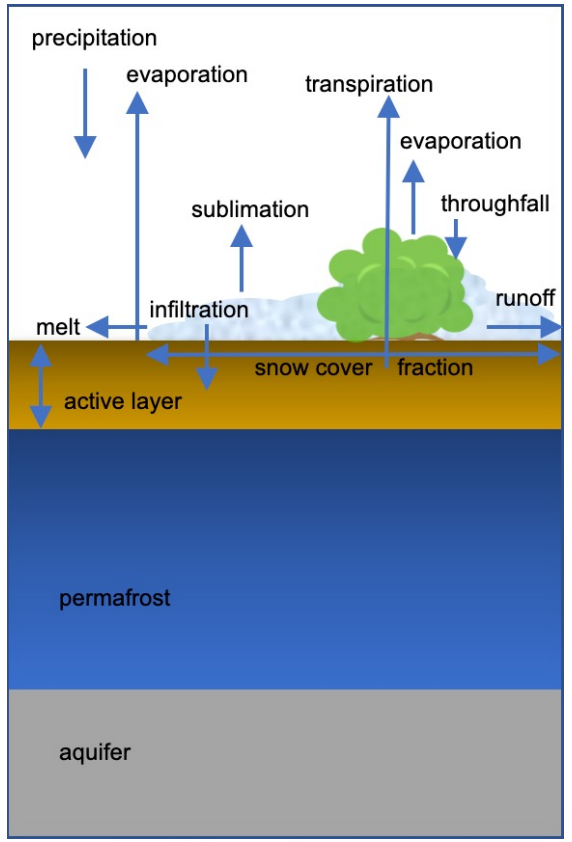

IM1
Inundation dynamics
IM2
Hillslope hydrology
IM3
Snow-vegetation-terrain interaction
IM4
Representation of tundra vegetation
IM5
Vegetation dynamics
IM6
Soil biogeochemistry

Integrated modeling: Improved representation of fractional inundated area, hillslope hydrology, and snow distribution



ATS meso scale and ML snow distribution models





E3SM Land Model

NGEE Arctic
Next-Generation Ecosystem Experiments

NGEE Arctic at LANL and beyond… the numbers

>140 NGEE Arctic team members

Current LANL team is 25 members

263 publications with >1,750 co-authors

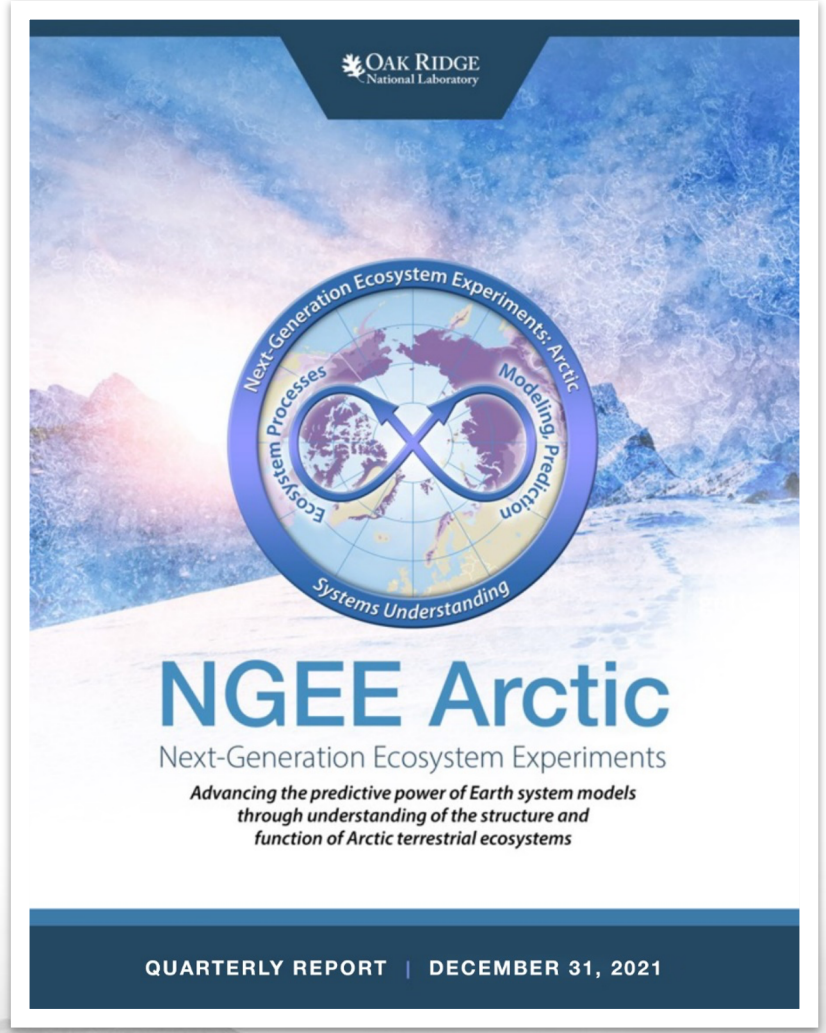
Cited >10,740 in 85 journals

207 data/metadata @ NGEE Arctic portal

129 public datasets @ NGEE Arctic portal

267 unique dataset downloads in 2021

7,534 sessions @ NGEE Arctic website 2021



The Next-Generation Ecosystem Experiments (NGEE Arctic) project is supported by the Office of Biological and Environmental Research in the DOE Office of Science.

We also thank the following Native Corporations for allowing us to conduct our research on the traditional homelands of the Inupiat people.

UIC Science – Mary's Igloo Native Corporation –
Council Native Corporation – Sitnasuak Native Corporation

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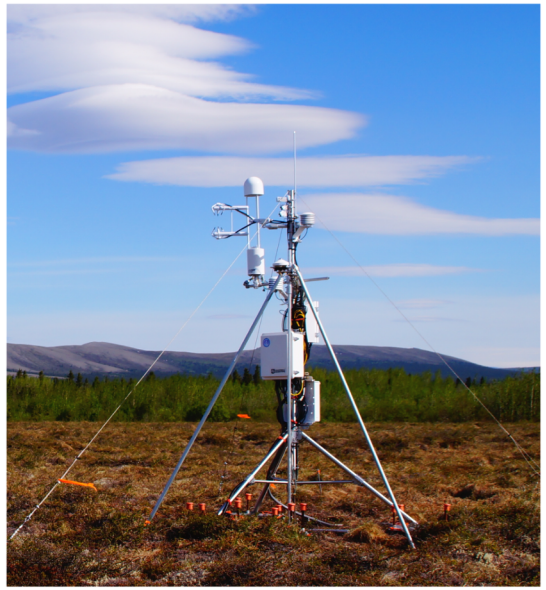
Extra Slides

Instruments (Seward Peninsula)



NGEE Arctic
Next-Generation Ecosystem Experiments

Data-model integration shows shift to deep groundwater pathways

Objective

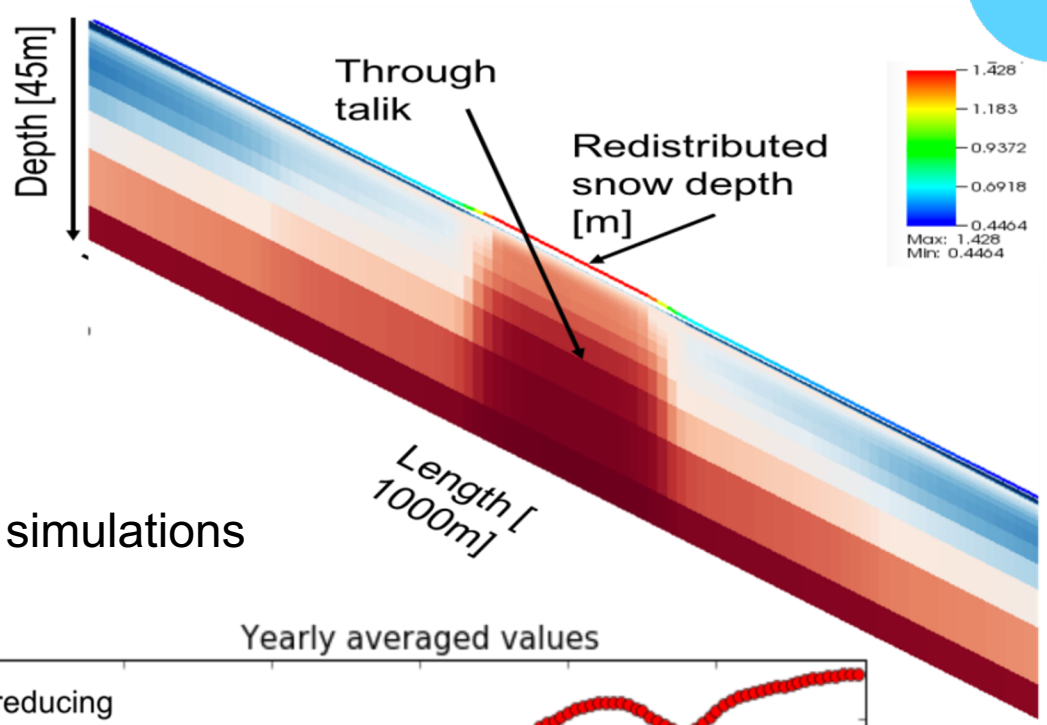
Explore how variation of key processes and parameters in space and time interact with permafrost distribution and evolution.

New Science

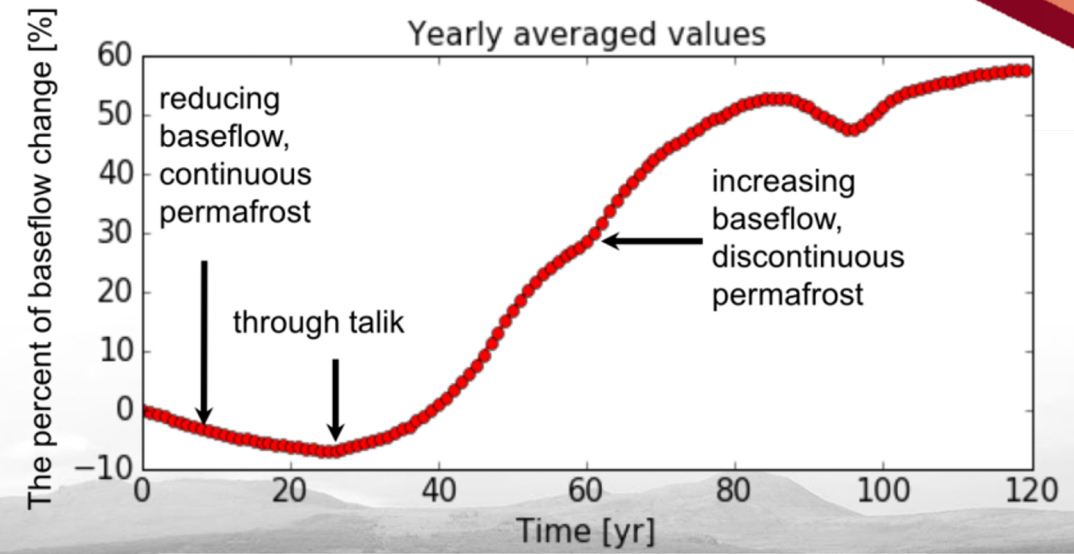
First simulations of 2-D surface/subsurface interactions and key controls on permafrost evolution in a hilly landscape.

Significance

New understanding of how changes in vegetation structure and patterns of winter precipitation and temperature will drive permafrost evolution. Simulations will enable snow parameterization for ELM.



ATS simulations



Discontinuous permafrost allowed 60% increase in baseflow

Diagnosing controls on sources and lateral water fluxes

Objective

Determine how permafrost and landscape structure influence lateral hydrologic pathways and residence times.

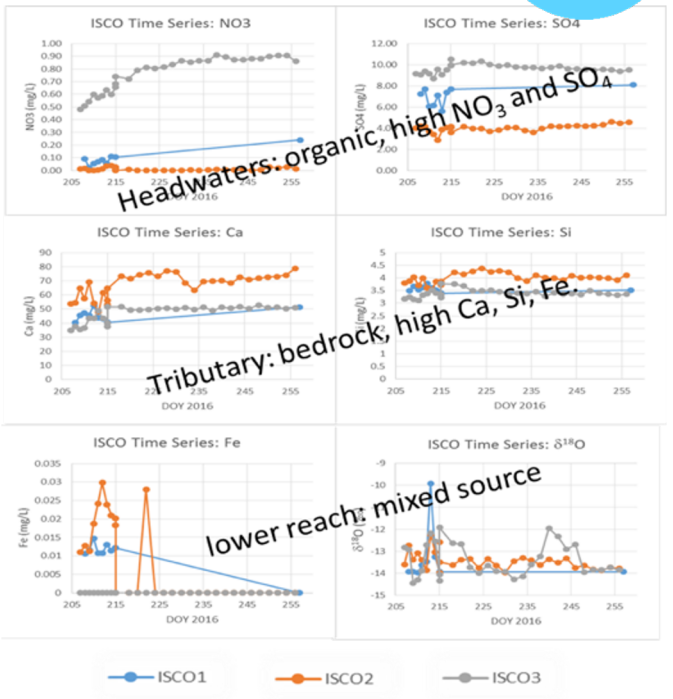
New Science

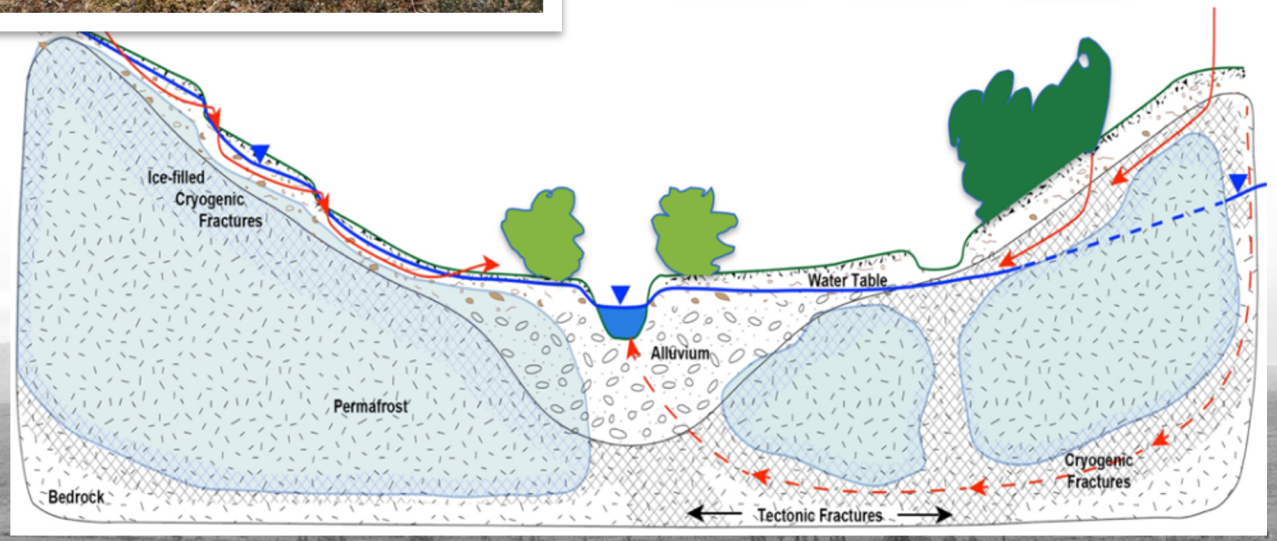
Combining Airborne NASA ABoVE SAR soil moisture, ground based geophysics and soil and stream geochemistry data to map hydrologic processes and pathways.

Significance

Benchmark data to inform fine scale to watershed scale models;

Apply data and models to assess role of shallow and deep lateral fluxes in permafrost landscapes for parameterized incorporation in ELM.





NGEE Arctic
Next-Generation Ecosystem Experiments

Snow, topography and vegetation interact to drive permafrost conditions

Objective

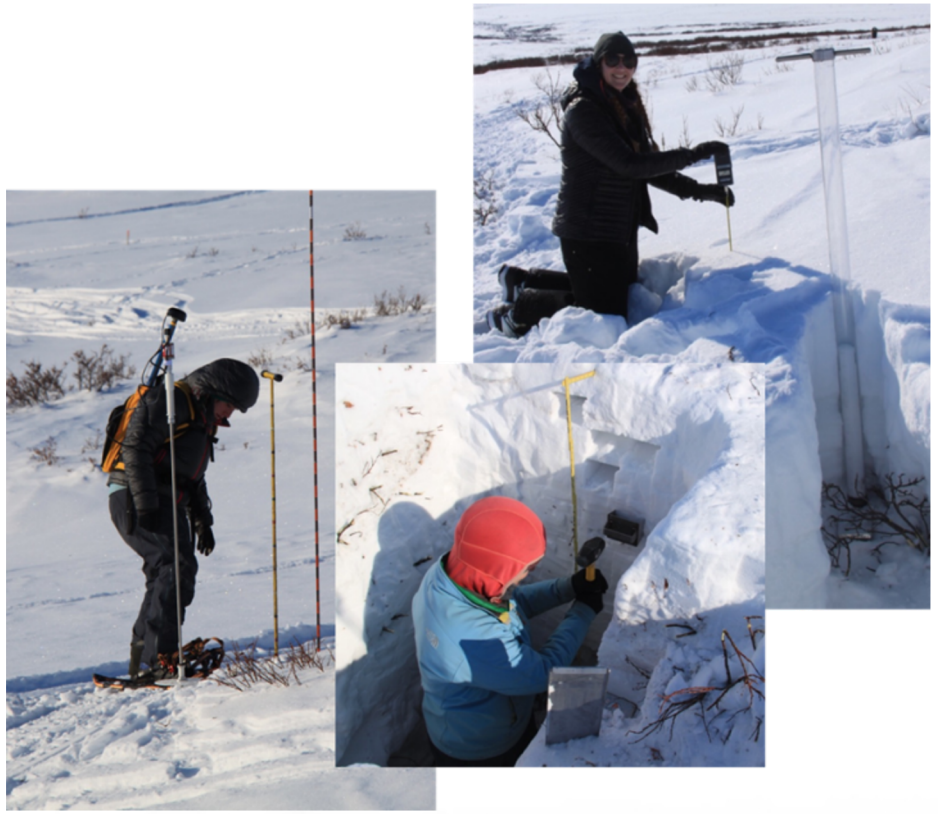
Develop comprehensive, high resolution, model-driven snow data set to quantify snow-landscape interactions and evolution.

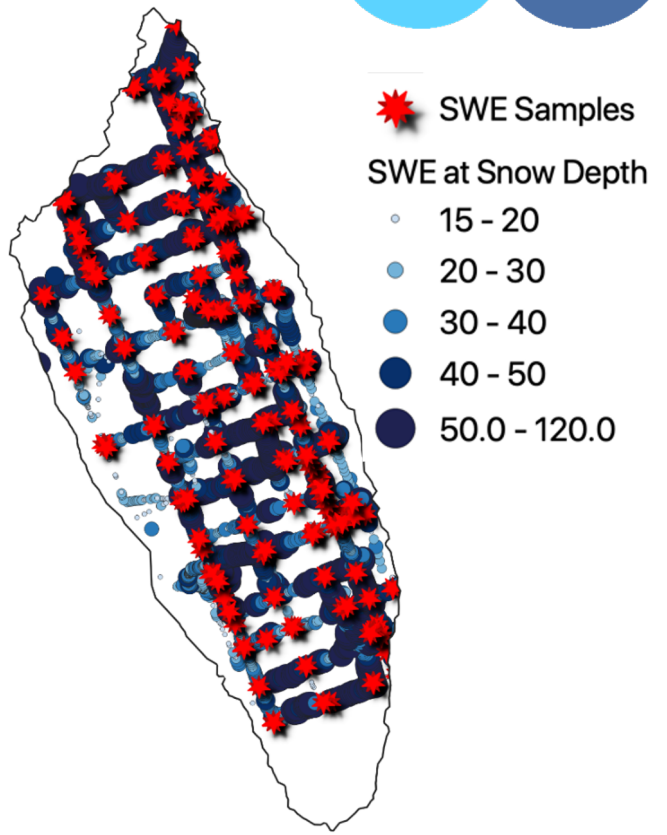
New Science

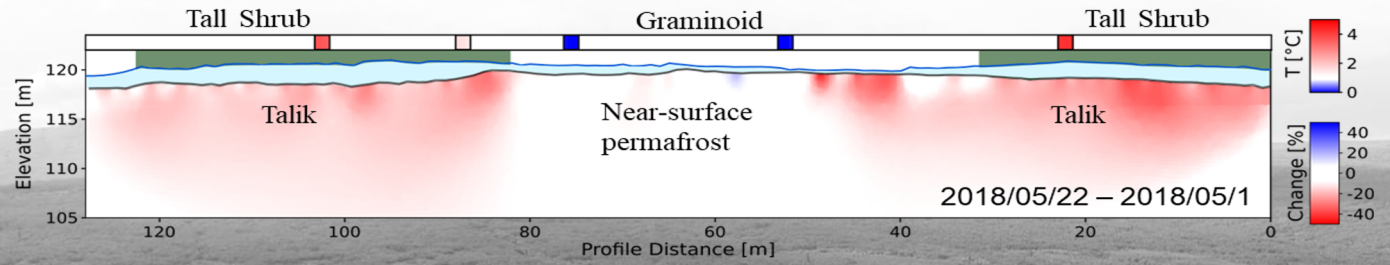
Combines high resolution watershed scale multi-platform measurements: vegetation and geophysics surveys, *in-situ* and geophysics-based snow depth & density, UAS snow elevation.

Significance

Benchmark data for watershed scale models to inform ELM.







NGEE Arctic
Next-Generation Ecosystem Experiments

Quantifying spatial controls on ecosystem function through UAS acquisitions, temperature sensors, and ecotype mapping

Objective

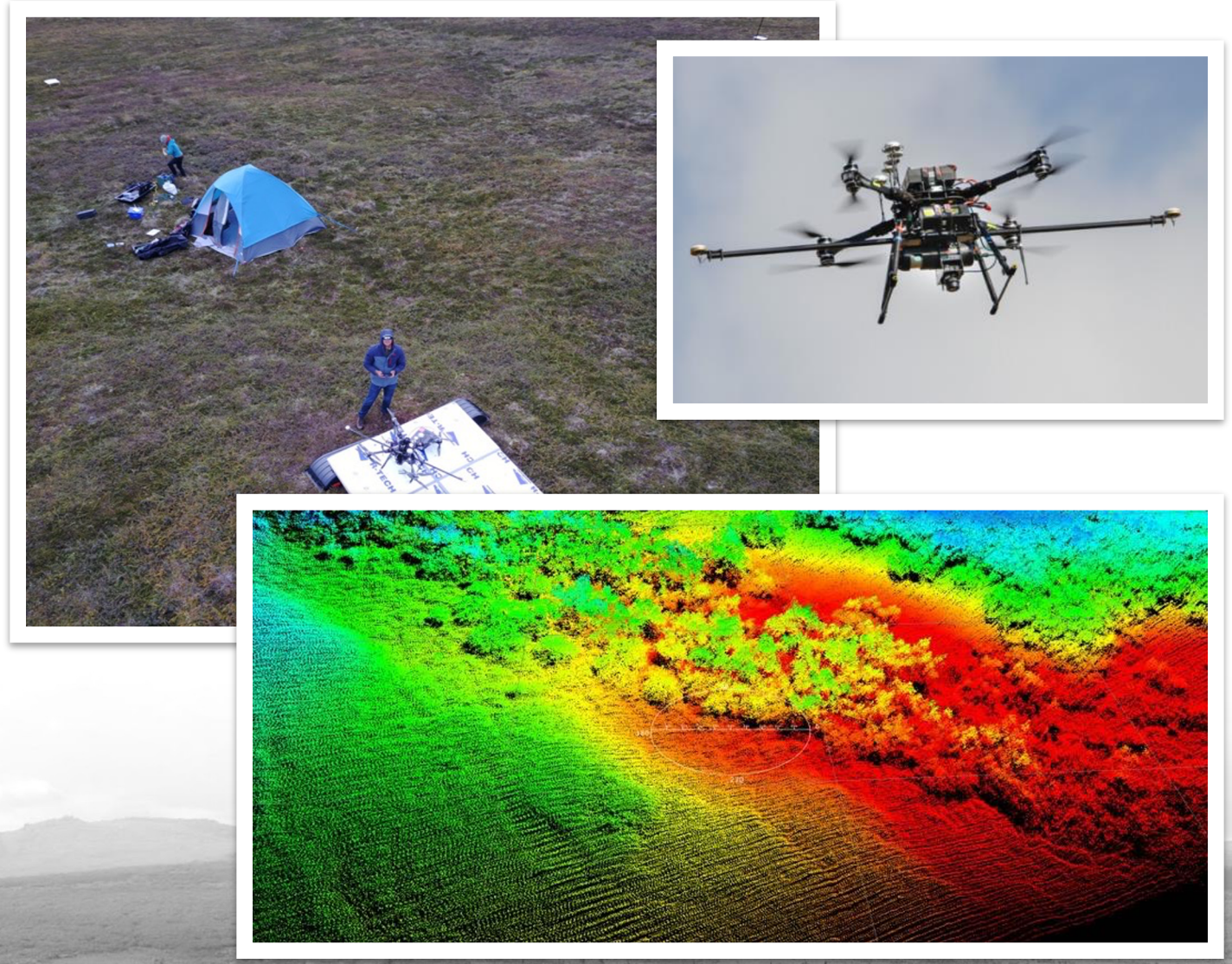
Create high resolution maps of physical and ecosystem patterns and processes using UAS technology.

New Science

Deployed multiple UAS platforms including cameras, spectrometers, gas analyzers and Lidar. Achieved high resolution spatial data, including 400 point / m^2 ground elevation and plant structure data.

Significance

Explore how landscape structure at different scales interacts/co-varies with physical and ecosystem processes to inform models.



Quantifying the rates, patterns and controls of rapid erosion and catastrophic landscape change

Objective

Quantify how permafrost and hydrological changes will alter sediment and carbon fluxes from watershed and alter the stability of landscape.

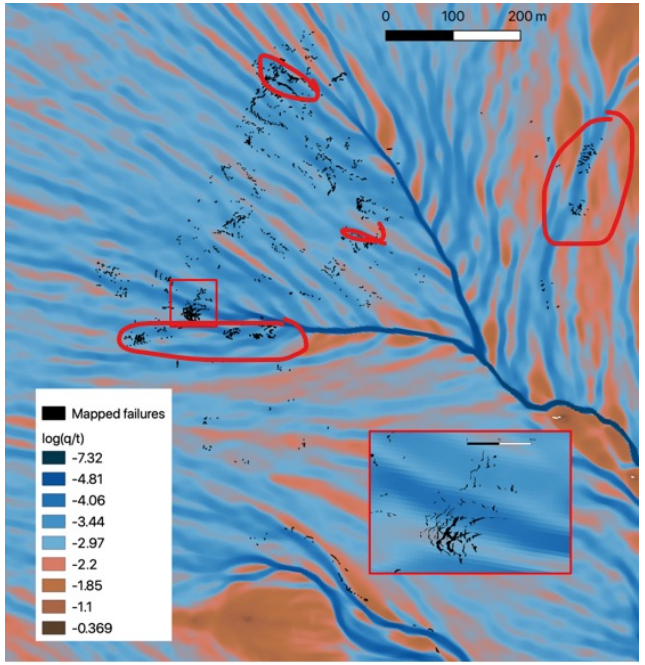
New Science

Use of multi-scale observations from subsurface to satellites to quantify how hillslope and watershed structure control the vulnerability and resilience of the Arctic to catastrophic change

Significance

Link hillslopes processes to rivers and stream and develop predictive models to quantify rapid change and erosion

Map of theoretical hillslope stability and actual failures



Catastrophic failures destablizing hills and accelerating erosion

Rapid thaw and erosion adding sediment and nutrients to streams

Community Outreach