Complex and Connected: A Multi-Scale Approach to Understanding the Arctic

Next-Generation Ecosystem Experiments (NGEE Arctic) Project

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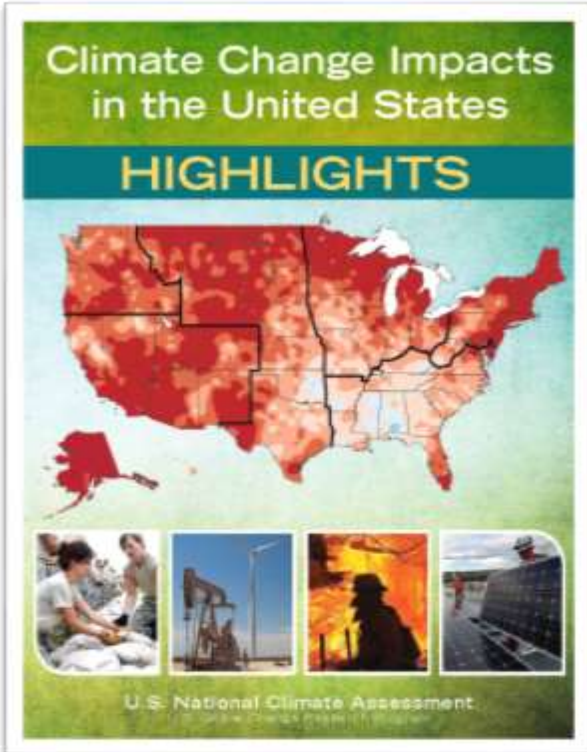


Permafrost temperatures in Alaska are rising, a thawing trend that is expected to continue, causing multiple vulnerabilities through drier landscapes, more wildfire, altered wildlife habitat, increased cost of maintaining infrastructure, and the release of heat-trapping gases that increase climate warming.

Temperatures have risen 3 ^{o}F in the last 60 years and are projected to continue this increase in the coming century.

10 – 12 ^{o}F in the north

8 – 10 ^{o}F in the interior

6 – 8 ^{o}F across the rest of the state.

Arctic Ecosystems and Climate Feedbacks

Permafrost soils contain about 1700 Pg C

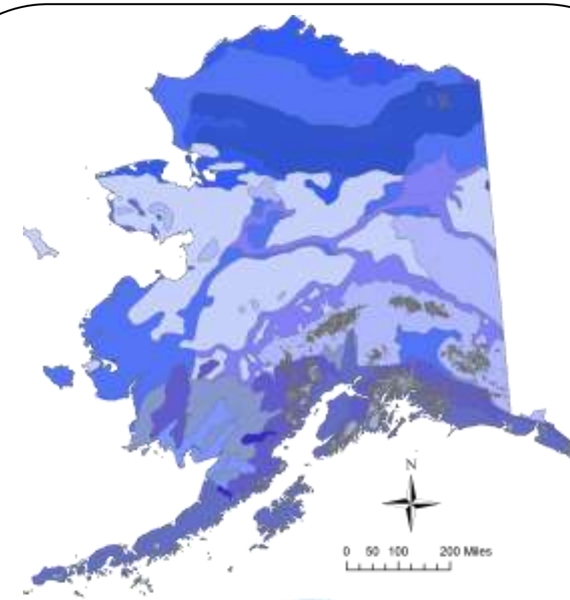
Point #1

7 to 90% of permafrost could be lost by 2100

Microbial decomposition of this C could represent a positive feedback to climate warming

Point #2

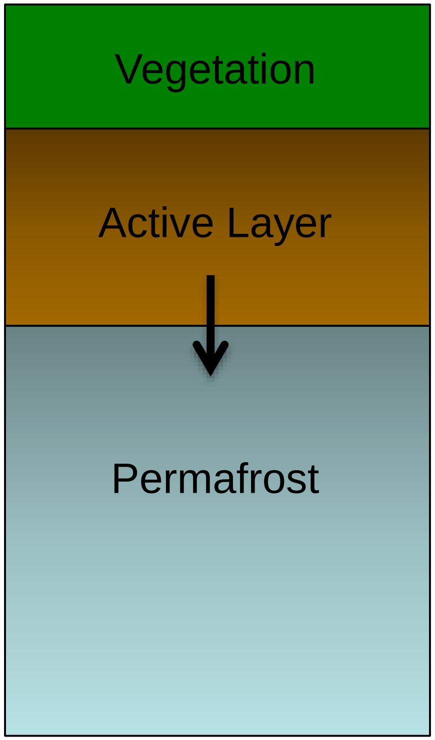
Cascade of interacting processes that involve changes in topography, water distribution across the landscape, and impacts on biogeochemical and biophysical feedbacks



Permafrost Thaw

Landscape Change

Climate Feedbacks



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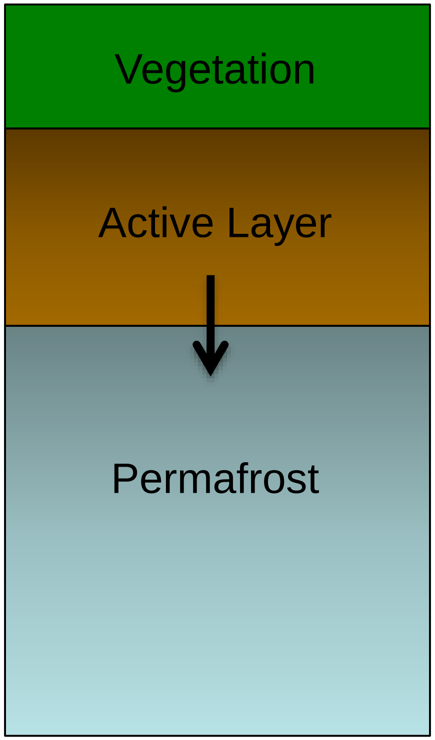
Carbon Cycle *and* Energy Balance Processes

Challenges of spatial and temporal complexity that arise given unique surface and subsurface interactions.

Permafrost Thaw



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Landscape Change

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Climate Feedbacks

Carbon Cycle *and* Energy Balance Processes

Challenges of spatial and temporal complexity that arise given unique surface and subsurface interactions.

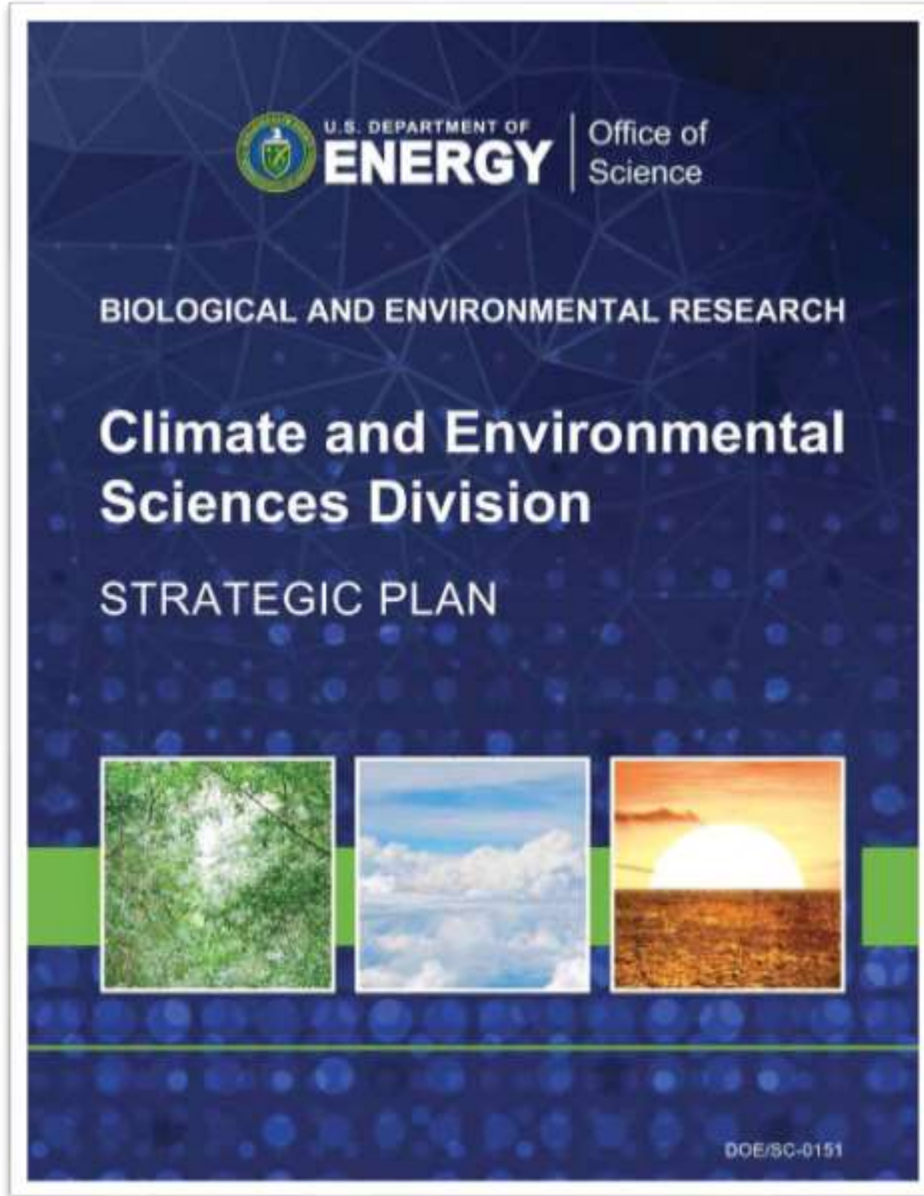

Arctic Climate Impact Assessment
Arctic Climate Impact Assessment
ACIA
Our Changing Planet
The U.S. Global Change Research Program
USGS
The United States National Climate Asses
Alaska Technical Regional Report
NASA
A Concise Experiment Plan for
The Arctic-Boreal Vulnerability Experiment
ABoVE
Arc
NOAA'S ARCTIC ACTION PLAN
LANDSCAPE
CONSERVATION
COOPERATIVES

Goal:

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

Mission:

To advance a robust predictive understanding of Earth's climate and environmental systems and to inform the development of sustainable solutions to the Nation's energy and environmental challenges.



Challenges and Approach:

…a process-rich ecosystem model

Mechanistic studies in the field and laboratory in order to understand not only what happens, but why.

…evolution of Arctic ecosystems

Fundamental studies to project trajectory of landscape change into the future.
Models that are capable of representing this change based on our structural and function knowledge of surface and subsurface systems.

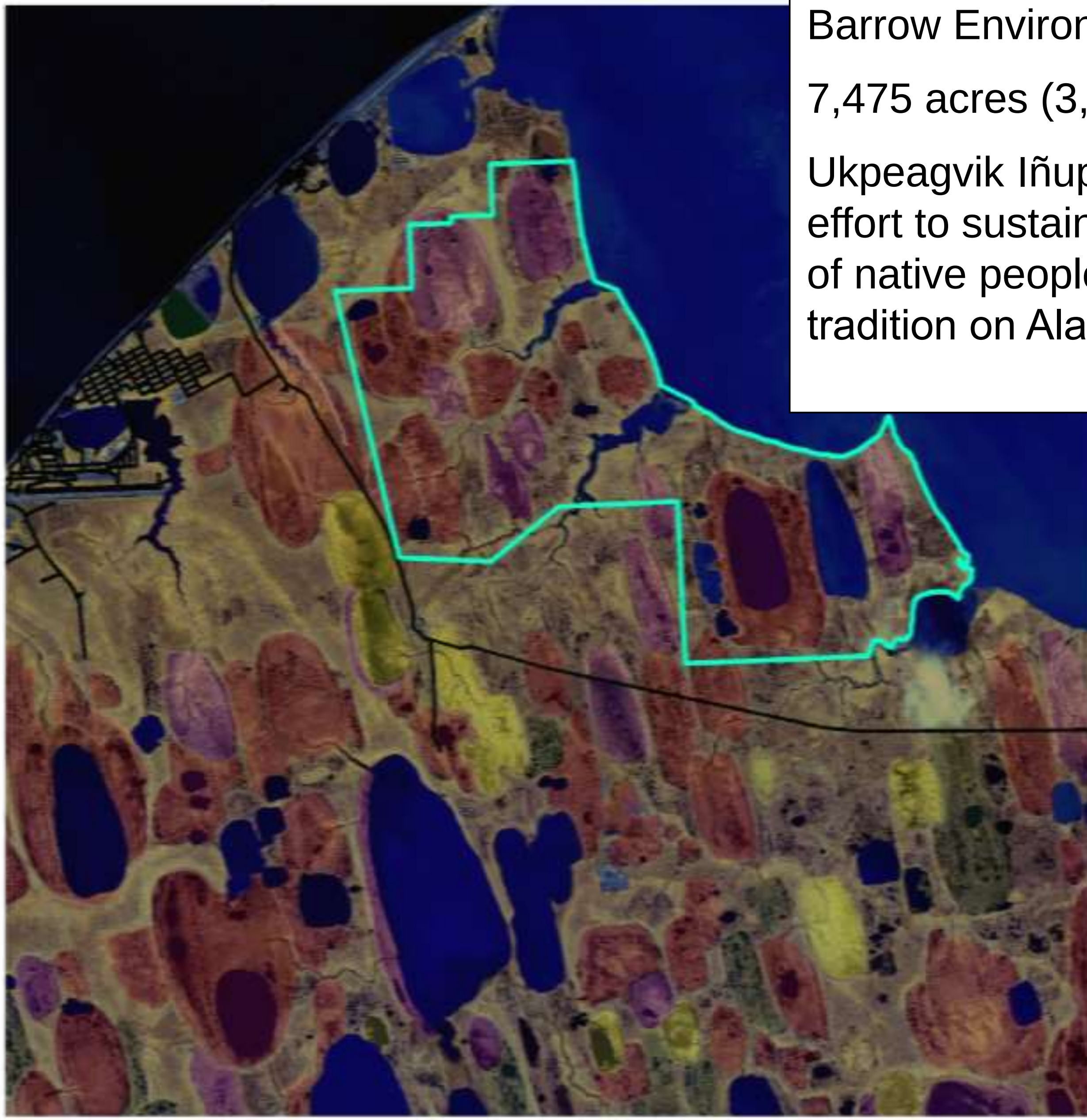
…scale of a high-resolution ESM grid cell

Our models must allow us to migrate information obtained in the field and laboratory to that of climate model, and do so taking into account landscape complexity.

Overarching Science Question:

"How does permafrost thaw and the associated changes in hydrology, soil biogeochemical processes, and plant community succession, affect feedbacks to the climate system?"

Geomorphology – Geophysics – Hydrology – Biogeochemistry – Vegetation Dynamics – Multiscale Modeling



Barrow Environmental Observatory (BEO)

7,475 acres (3,025 ha)

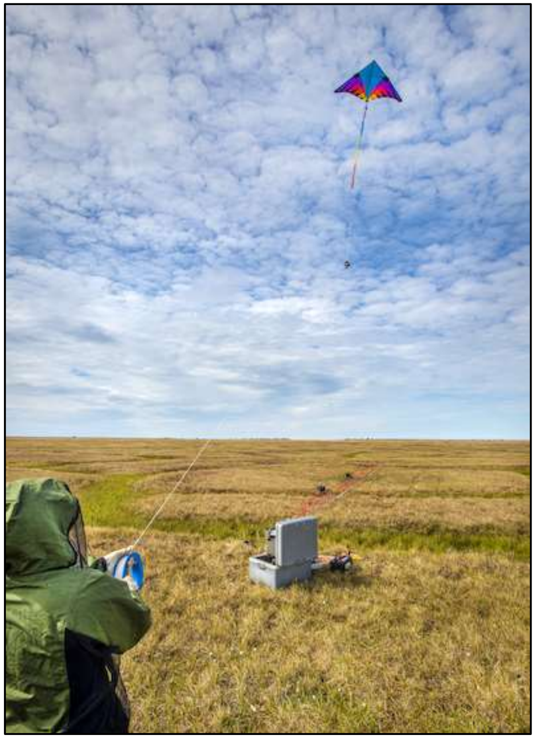
Ukpeagvik Iñupiat Corporation (UIC) in an effort to sustain the long-term commitment of native people to the scientific research tradition on Alaska’s North Slope.


NASA CARVE


NOAA ESRL


DOE ARM

Geomorphology



There is evidence that subsurface structures are responsible for surface features, and that microtopography drives variation in water, inundation, and vegetation composition.

Geophysics

Strong interactions exist between surface and subsurface properties, especially distribution of cyrostructures and influence on surface topography as measured using multiple geophysical techniques.

Geophysics (April, 2014)

Hydrology

Surface topography of the Arctic Coastal Plain, although subtle, drives distribution of snow, snow depth, timing of snow-melt, and discharge of water from across the landscape. Micro-topographic features (e.g., rims and troughs) also determine composition of vegetation and CO_2 and CH_4 production.

Biogeochemistry

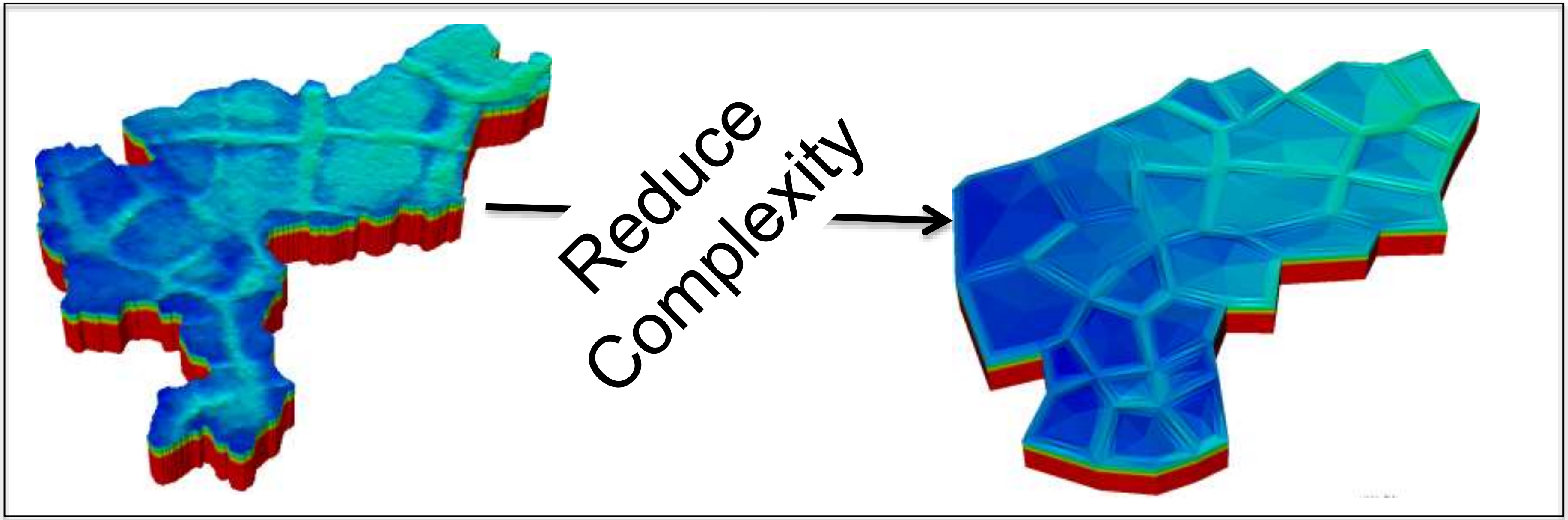
Fluxes of CO_2 and CH_4 are controlled by a complex combination of temperature, moisture, geochemistry, and microbial processes that vary with depth in soil.

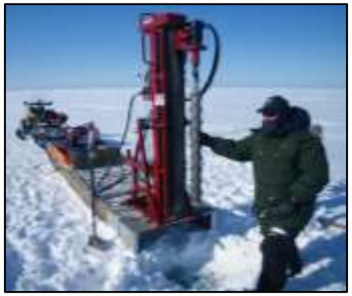
Biogeochemistry

Vegetation Dynamics

Critical parameters used in climate models to describe plant productivity and uptake of CO_2 for Arctic vegetation do not reflect field measurements as conducted by NGEE Arctic plant physiologists.

Multiscale Modeling





We are working to develop, test, and evaluate a multi-scale framework that includes field, laboratory, and modeling for improved process knowledge in the Arctic, and then improved global climate prediction.

NGEE Arctic: Emphasizing permafrost thaw, degradation, and landscape evolution in a warming climate.

Field and Laboratory Studies

- New parameters and algorithms
  - Landscape change
  - Plant types
  - Root function
  - Biogeochemistry
  - Hydrology
- Initialization
  - Topography
  - Geophysical characterization
  - Plant distribution
  - Soil carbon stocks and distribution
- Evaluation
  - Eddy covariance estimates of flux
  - Water discharge
  - Energy exchange and albedo
- Discovery science

Model-Knowledge Integration

Climate Scale

"Down-scaling"

"Up-scaling"

Plot Scale

Opportunities to Collaborate

- Leverage investments and facilitate continued scientific collaboration in Barrow, Alaska (Phase 1).
- Affiliate with other projects to understand Arctic ecosystems and feedbacks to climate (e.g., AON, NEON, ABoVE, CARVE, PAGE21).
- Encourage single PI interactions with NGEE Arctic investigators.
- Synthesis activities; workshops; facilitate model inter-comparisons.
- Share resources; make datasets available, permafrost samples, etc.

NGEE Arctic Web-Based Resources

Web site: http://ngee-arctic.ornl.gov/

Blog: http://ngee-arctic.blogspot.com/

Flickr: https://www.flickr.com/photos/ngee-arctic/

NGEE Arctic Forum: Coming soon

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

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Logistical Support Provided by:

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