

Measurements and Models: A Multi-Scale Approach to Understanding Arctic Ecosystems

Next-Generation Ecosystem Experiments (NGEE Arctic) Project

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U.S. DEPARTMENT OF
ENERGY



BROOKHAVEN
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Arctic Ecosystems and Climate Feedbacks

Permafrost soils contain about
1700 Pg C

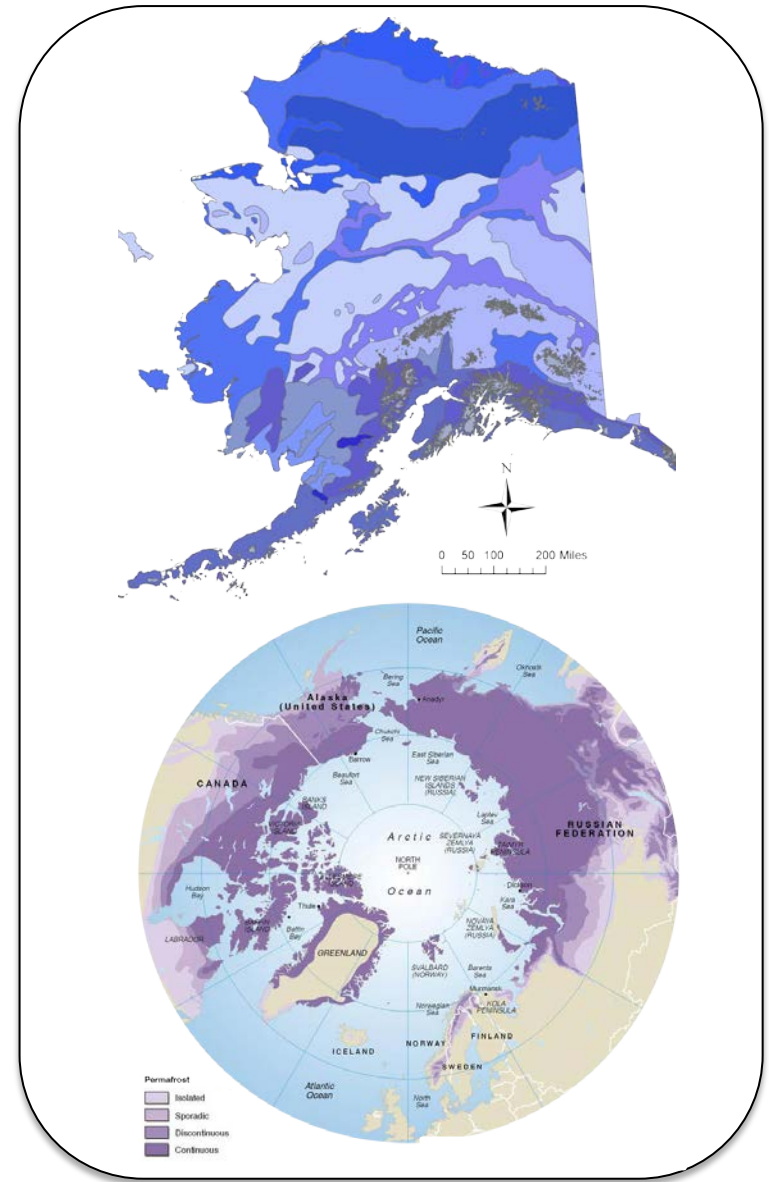
Point #1

7 to 90% of permafrost could be
lost by 2100

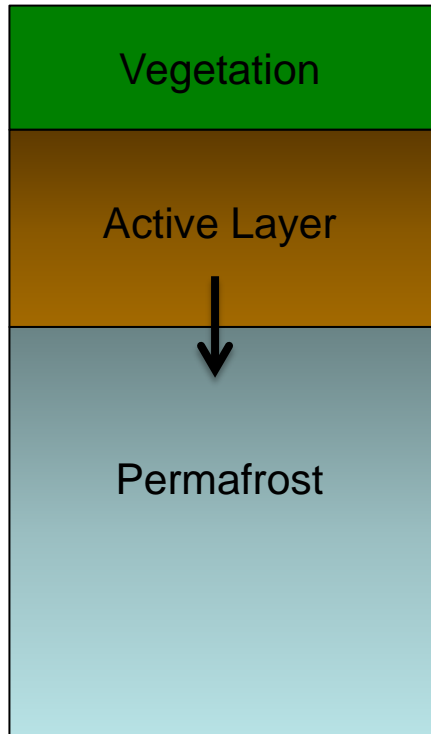
Microbial decomposition of this
C could represent a positive
feedback to climate warming

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

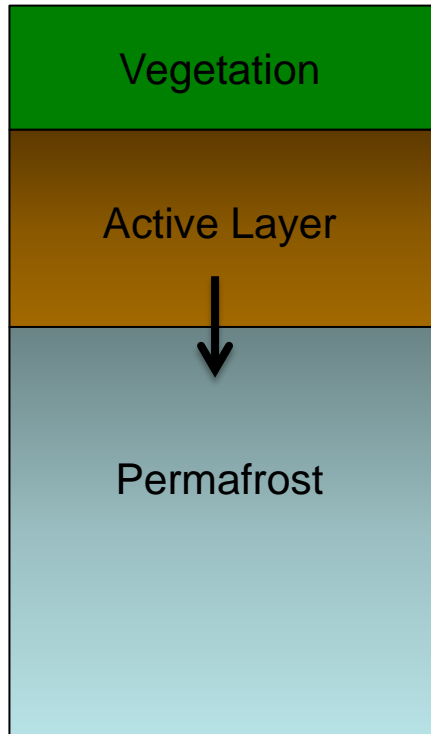


Climate
Feedbacks

= 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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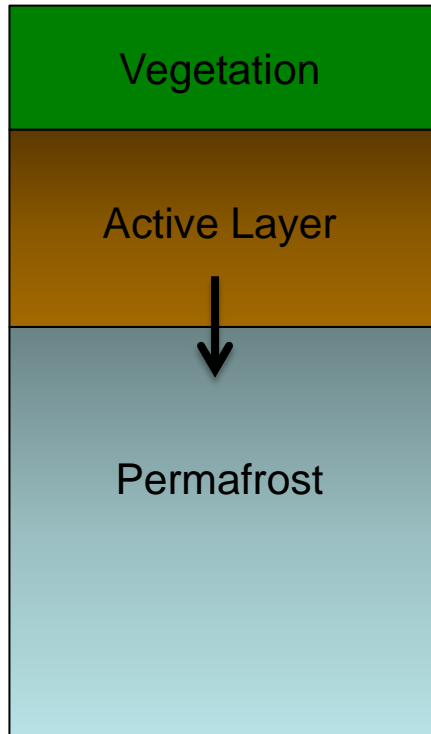


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Goal:

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 ESM grid cell.



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 characterize and project landscape change into the future.

Models that are capable of representing this change based on our structural and functional knowledge of surface and subsurface systems.

...scale of a high-resolution ESM grid cell

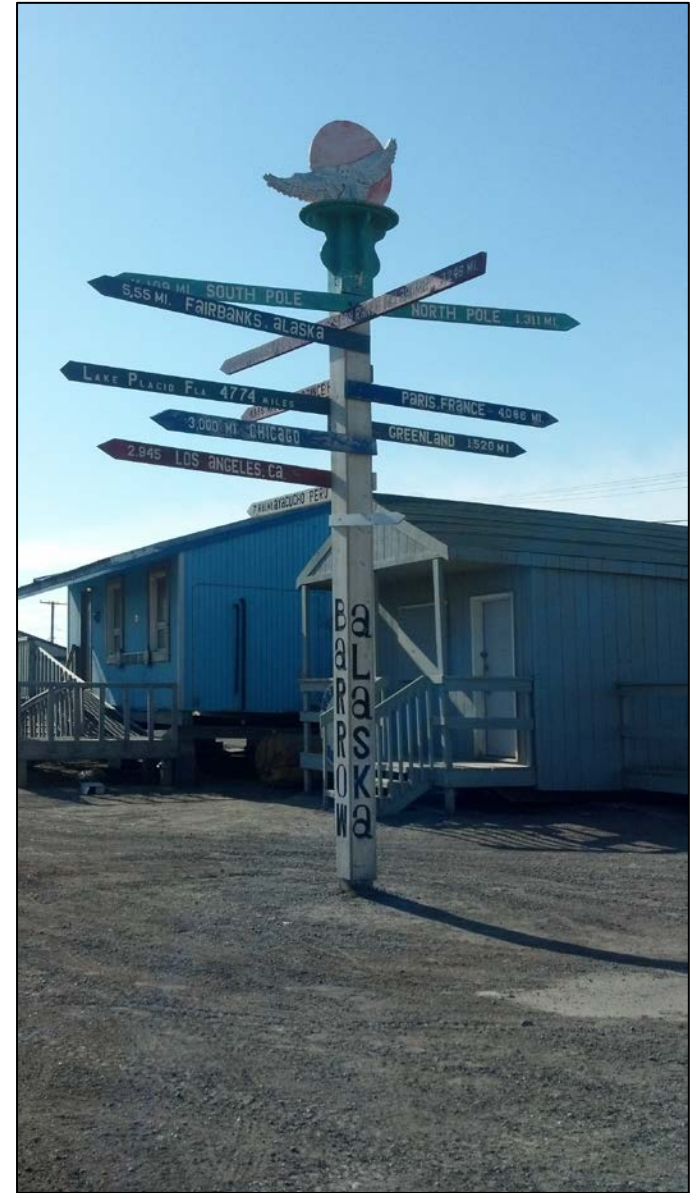
Our models must allow us to migrate information obtained in the field and laboratory to that of climate model, and do so taking into account landscape complexity.

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**





NASA CARVE



NOAA ESRL



DOE ARM



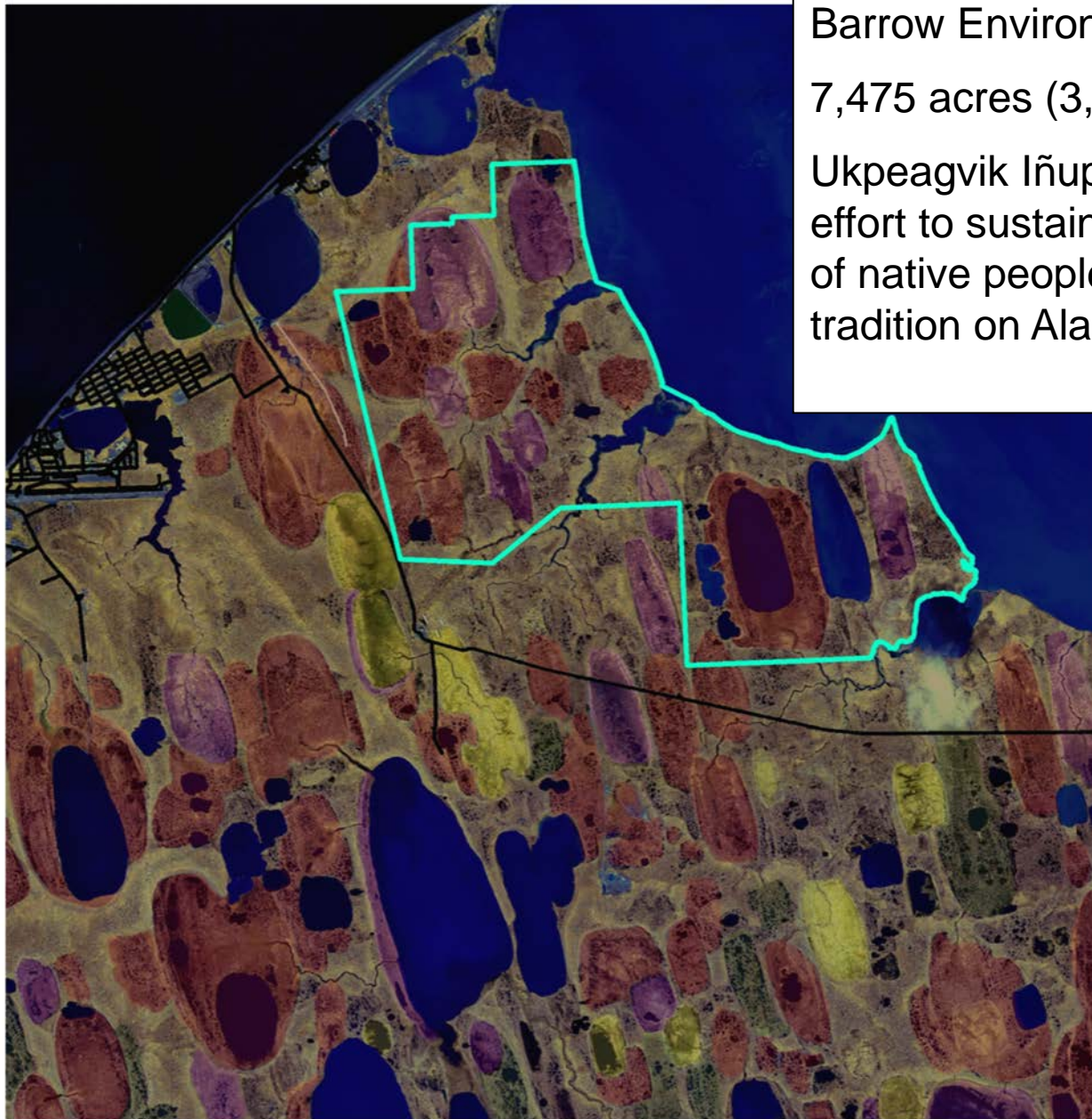
Barrow Arctic Research Center (BARC)



Barrow Arctic Research Center (BARC)

BARC 133





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.



Geomorphology



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



Geophysics



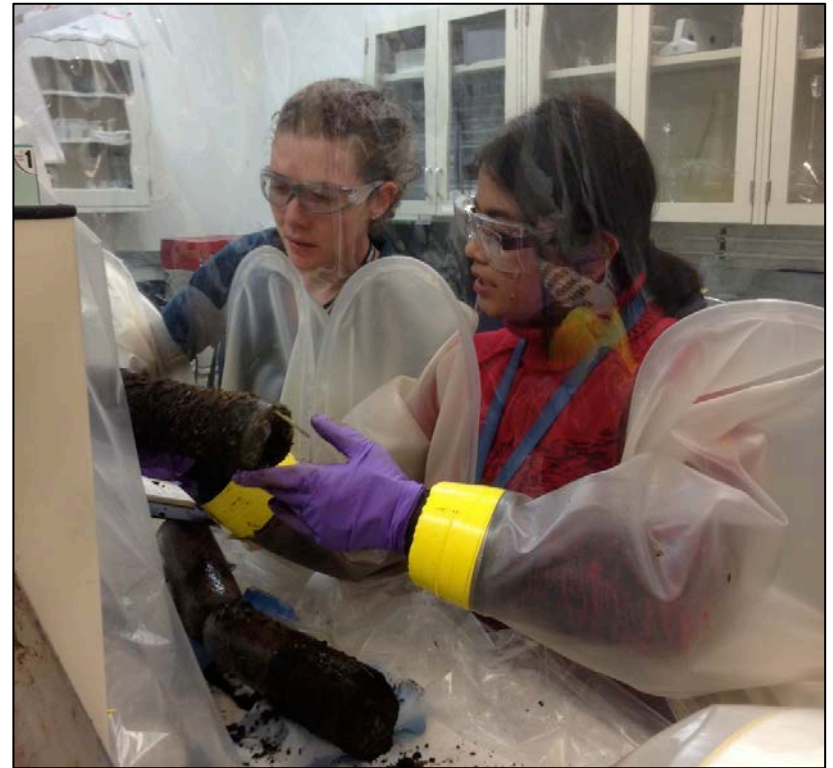
Strong interactions exist between surface and subsurface properties, especially distribution of cryostructures and influence on surface topography as measured using multiple geophysical techniques.



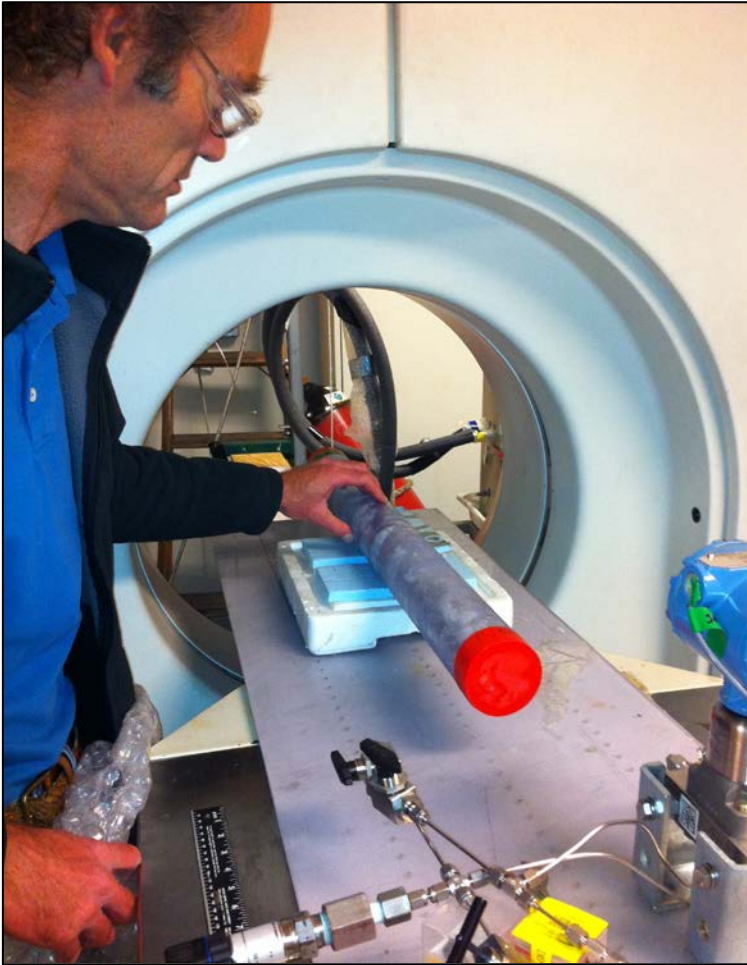
Biogeochemistry



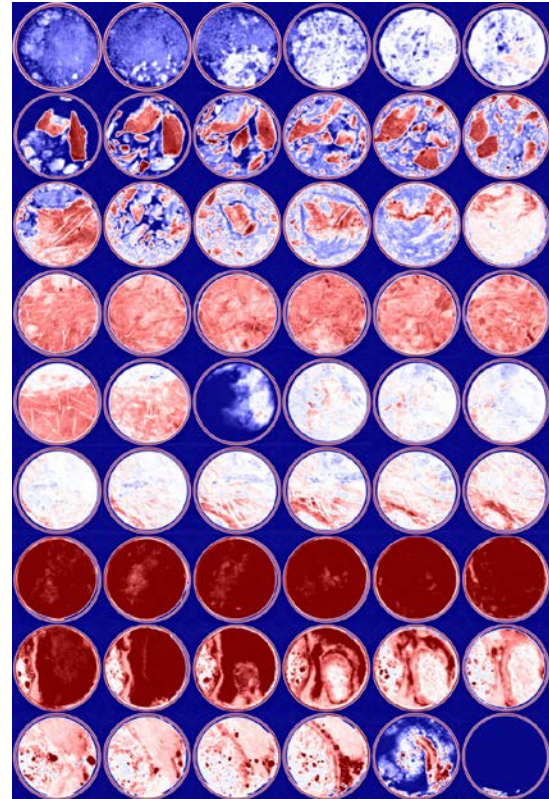
Fluxes of CO_2 and CH_4 are controlled by a complex combination of temperature, moisture, geochemistry, and microbial processes that vary with depth in soil.



Biogeochemistry



Tim Kneafsey (LBNL)



0 – 6 cm

7 – 12 cm

13 – 18 cm

19 – 24 cm

25 – 30 cm

31 – 36 cm

37 – 42 cm

43 – 48 cm

49 – 54 cm

Qualitative Legend

White: density close to 1 ~ ice

Red: higher density ~ mineral soil

Blue: low density ~ organic matter, voids

Hydrology



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

Vegetation Dynamics

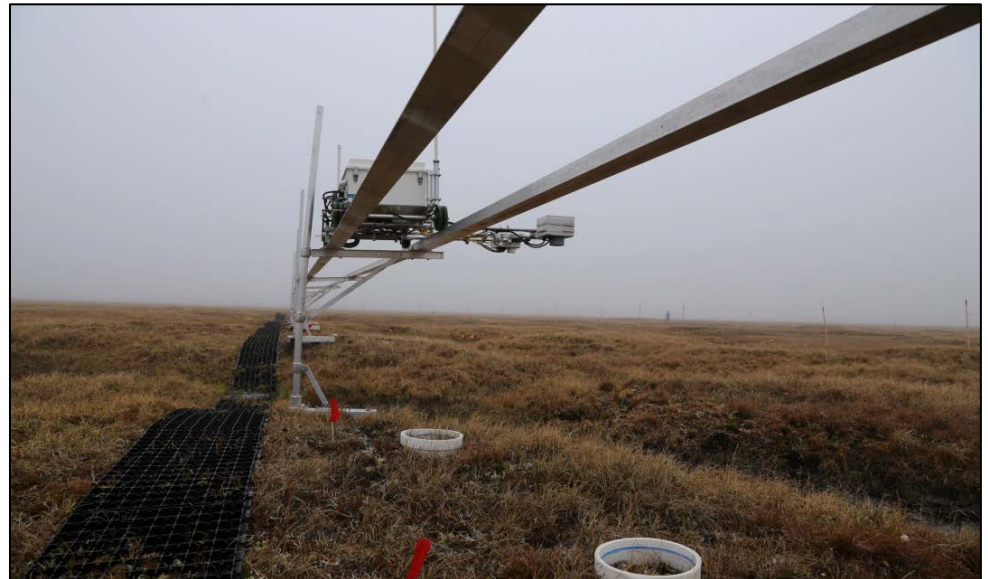
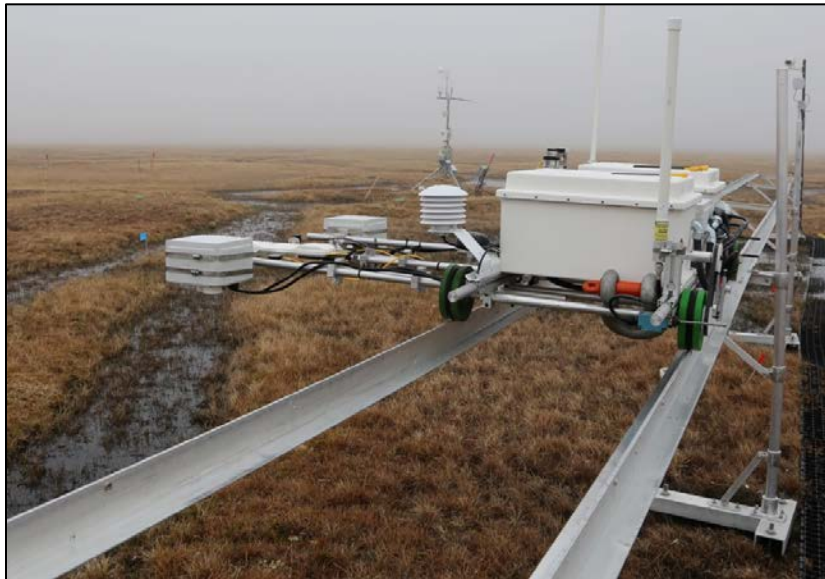


Critical parameters used in climate models to describe plant productivity and uptake of CO_2 for Arctic vegetation do not reflect field measurements as conducted by NGEE Arctic plant physiologists.

Energy Balance



65-meter tram along which an automated cart traverses the polygonal landscape every 3 hours. Tram is co-located within eddy covariance footprint, geophysics ERT array, soil moisture, temperature, and CO₂ and CH₄ flux chambers.



Energy Balance

Sensor

Net Radiometer

IR Surface Temperature

Par up and down

Spectral Red/NIR up and down

Spectral Green/Blue up and down

Spectral SWIR up and down

Spectroradiometer (310-1100 nm)

Hyperspectral (350-2500 nm)

Thermal Camera

Air Temp

Sonic depth sensor

Digital Camera

Purpose

Albedo; long and short wave net radiation

Skin temperature of land surface

Absorbed/reflected photosynthetically active radiation

NDVI- vegetation index

NDWI- spectral water index (leaf and soil water)

NDWI- spectral water index (leaf and soil water)

Near-surface remote sensing; scaling to satellite

Fine scale surface/leaf properties (campaign mode)

Spatial distribution of surface temperature

Calibrate sonic depth sensor

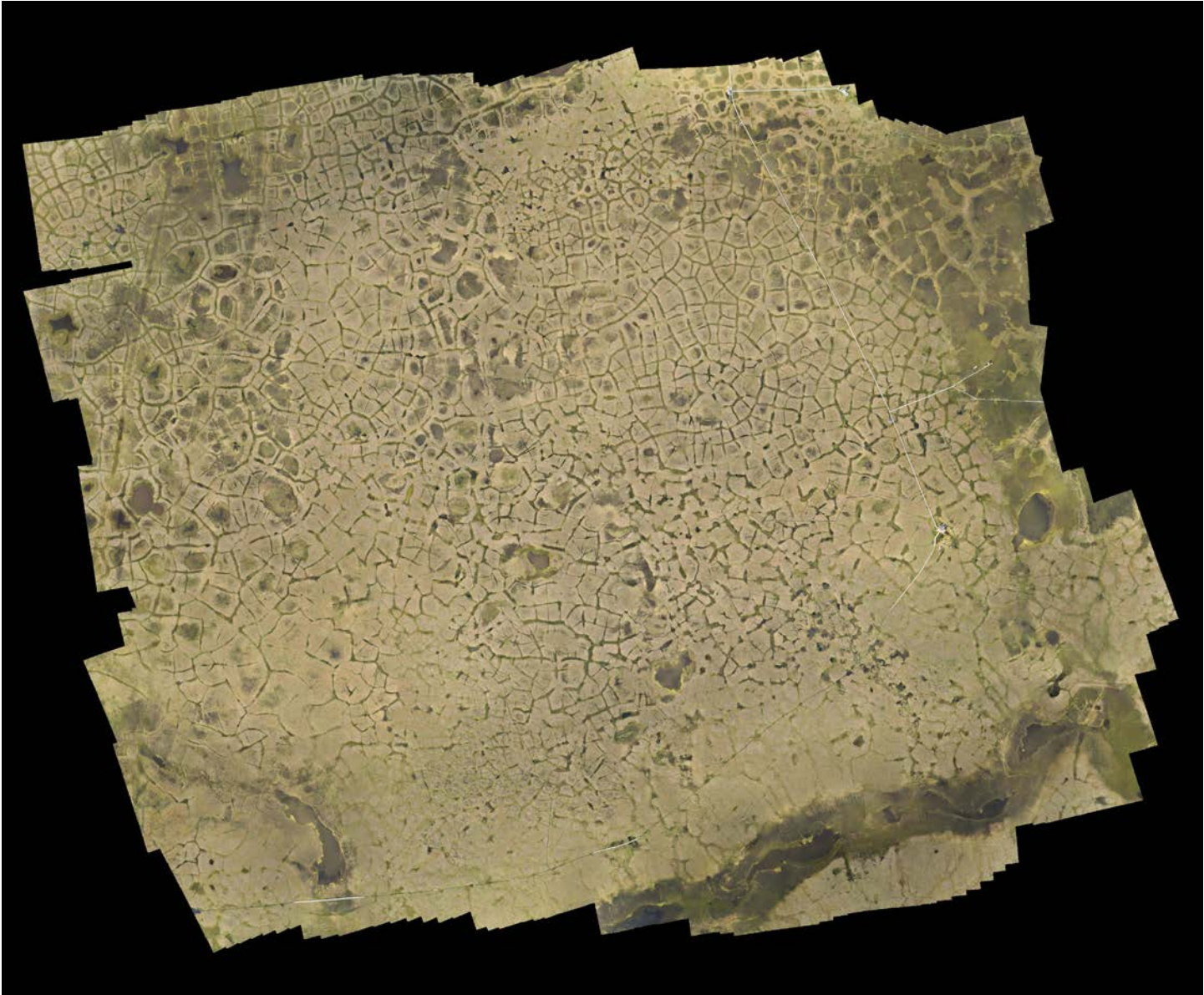
Snow and water depth

Digital image of each measurement period

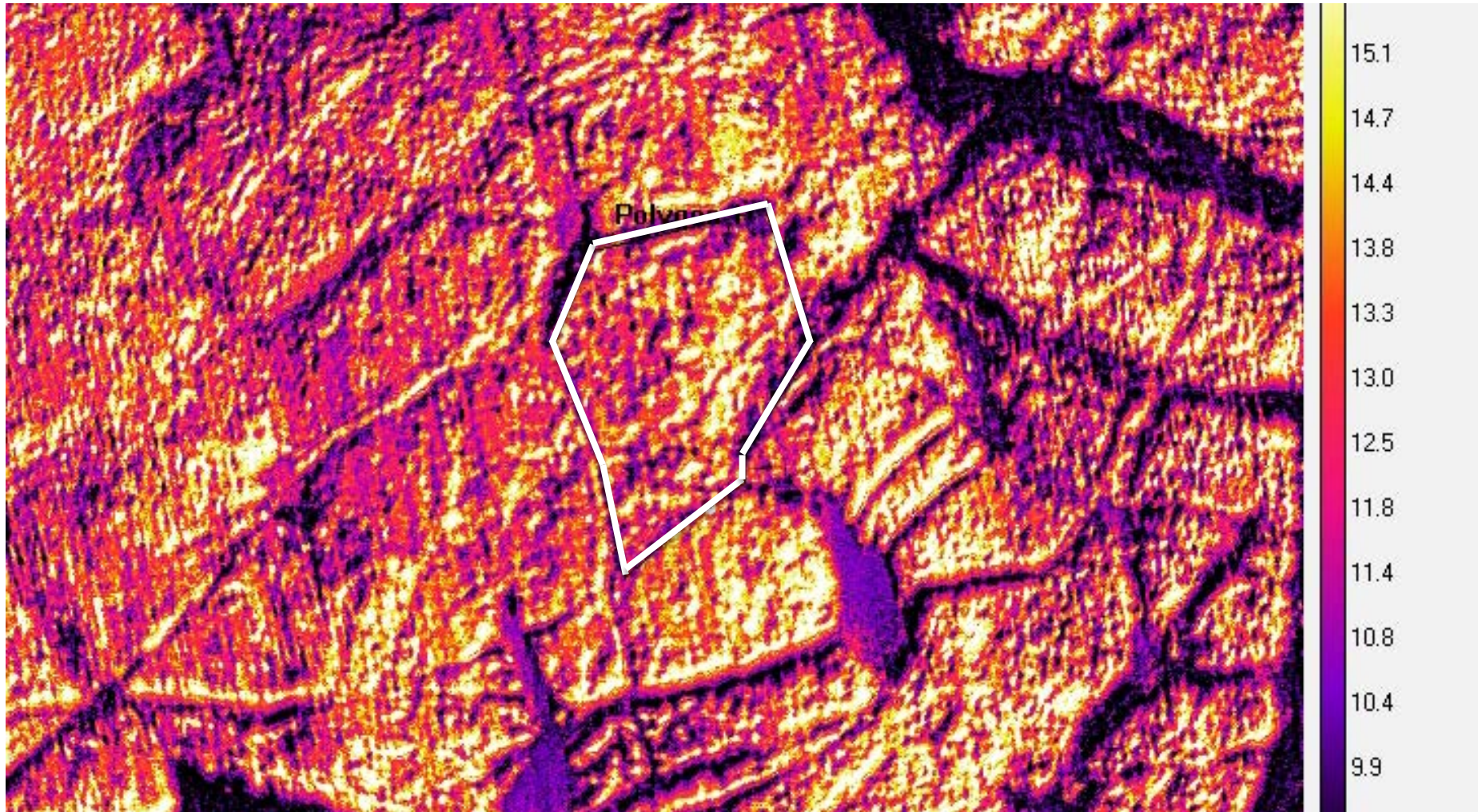
Energy Balance



High-Resolution Mapping (Jessica Cherry)

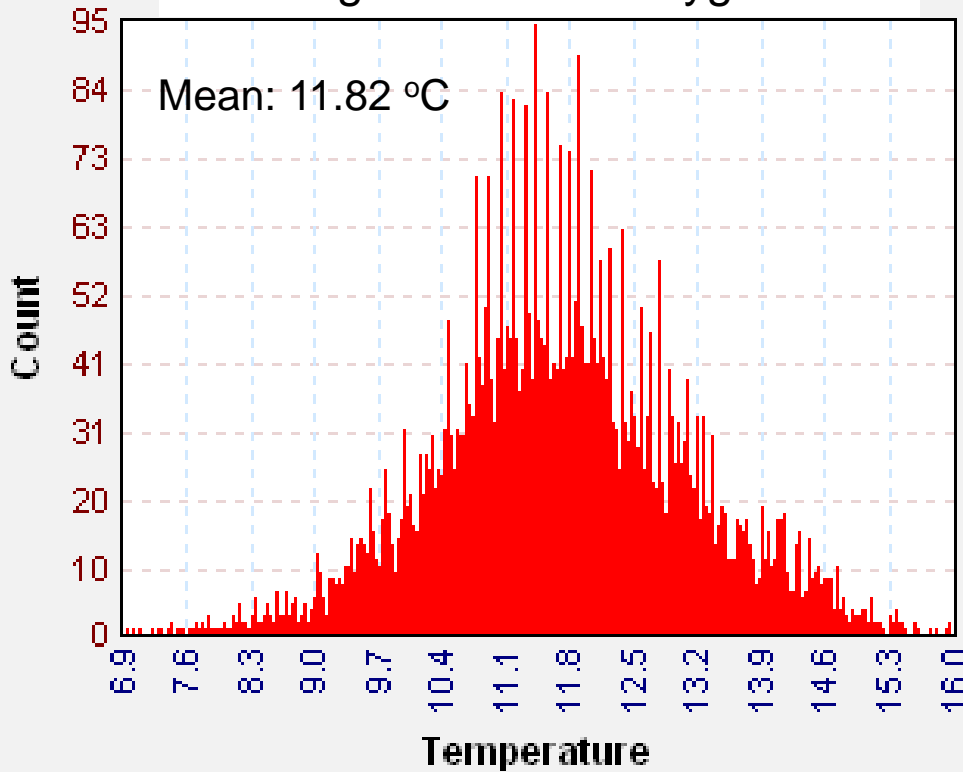


Energy Balance – Skin Temperatures

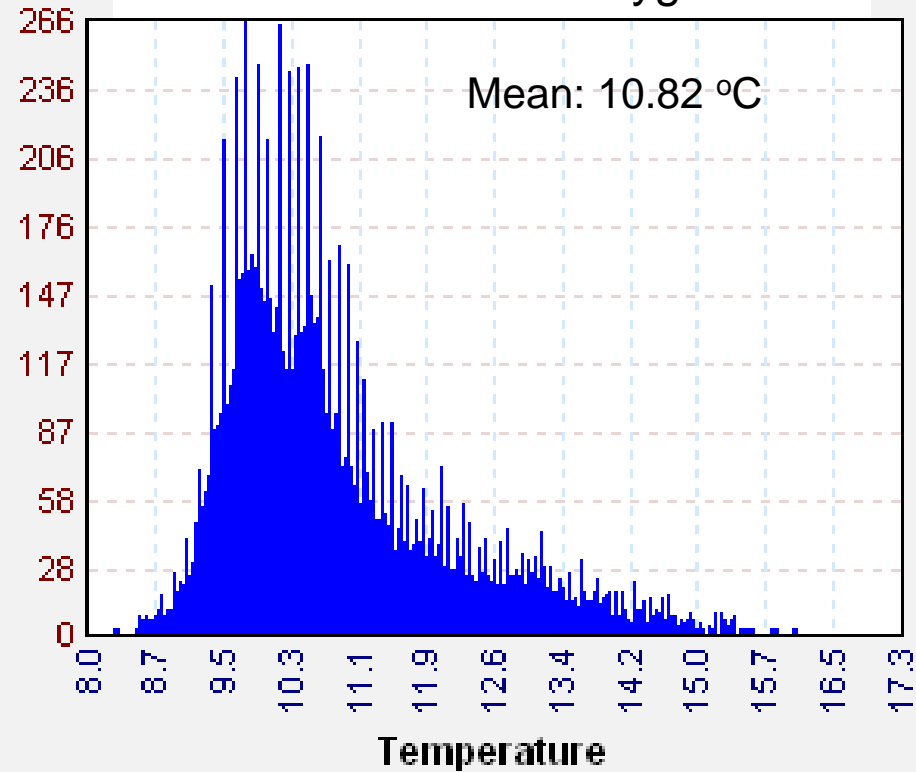


Energy Balance – Skin Temperatures

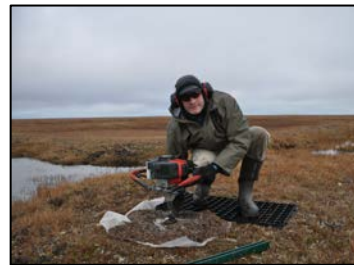
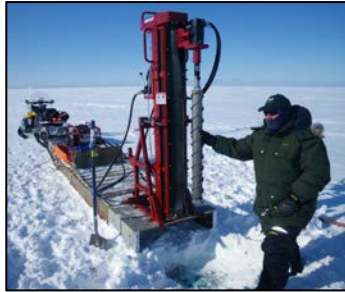
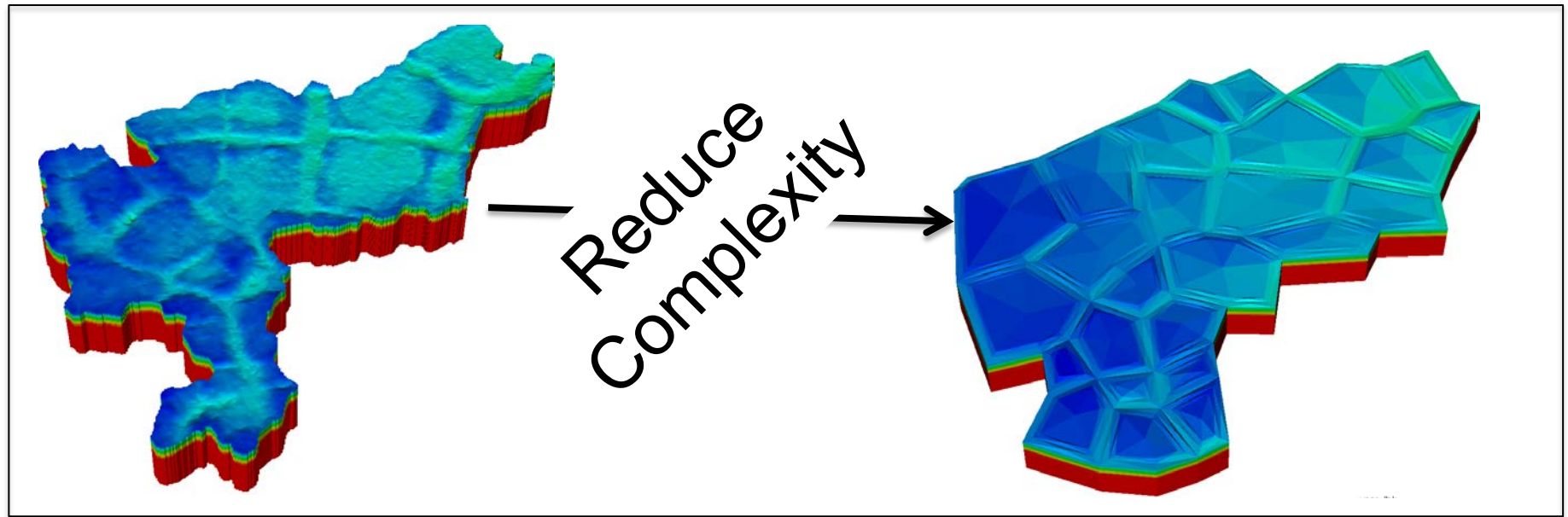
High Centered Polygon



Low Centered Polygon



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.

Opportunities to Collaborate

- Encourage scientific collaboration on the North Slope and Seward Peninsula, Alaska.
- Affiliate with other projects to understand Arctic ecosystems and feedbacks to climate (e.g., ARM, ASR, ABoVE, CARVE, PAGE21).
- Encourage single PI interactions with NGEA Arctic investigators.
- Synthesis activities; workshops; facilitate model inter-comparisons.
- Share resources; make datasets available, samples, etc.



Opportunities to Collaborate

ARM/ASR Joint User Facility PI Meeting

Wednesday, March 18, 2015

1:30 pm – 3:30 pm

Breakout Session 2

ARM/ASR/NGEE Arctic: Building Collaboration in Alaska

Wullschleger, Ivey, Shupe [Great Falls]

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/>

Data Portal: <http://ngee-arctic.ornl.gov/data/>

Data Management Tools

NGEE Arctic and ARM Data Teams share tools:

- Metadata Registration Form (OME)
- Digital Object Identifier (DOI) workflow
- Data Search tool (Mercury)



NGEE Arctic-ARM Data Sharing

Data teams worked on a data sharing strategy.

ARM metadata records (136) are published in NGEE Arctic data search tool.

Users can search and discover ARM Barrow data using the NGEE Arctic Search Tool.

Users are redirected to ARM data access tool for downloading the ARM data.

What is next: NGEE Arctic data will be made available to the ARM user community using a similar approach.

The screenshot displays the NGEE Arctic Data Search BETA web application. At the top, a green header bar contains the site name and navigation links. Below the header, a search bar with a magnifying glass icon and the text 'Data Search' is visible. To the left of the search results, a sidebar shows a map of the Arctic region and a list of keywords and federal agencies. The main content area displays a list of search results, each with a title, data source, federal agency, and date range. Each result has a 'Related Dataset' button and 'Get Data' and 'View Metadata' links.

NGEE Arctic - Data Search BETA

Home | NGEE Arctic Website | Create Metadata | H

(press ESC to close suggestions)

Data Search

7 Results

Current Selection(s):
X keywords: "surface properties"

Geography

Enlarge Map

Keyword

- (jpeg) (2)
- albedo (2)
- arm (7)
- arm derived product (3)
- arm observed data (4)
- arm shortwave flux analysis (2)
- arm tower camera (2)
- atmospheric radiation measurement (7)
- atmospheric state (2)
- more

Federal Agency

- Department of Energy (7)

Data Originator

- Atmospheric Radiation Measurement (7)

Scientist

- Campos, Edwin (2)
- Cook, David (2)
- Gaustad, Krista (2)
- Martin, Timothy (2)
- McFarlane, Sally (2)
- Stuefer, Martin (2)

< 1 > displaying 1 to 7 of 7

Results: 10 Sort By: Relevance

Short Wave Flux Analysis: 15-min resolution on SKYRAD data, Long algorithm at North Slope Alaska Related Dataset

Data Source: Atmospheric Radiation Measurement Begin Date: 03/31/1999 End Date: 12/31/2014

Federal Agency: Department of Energy

The SW (shortwave) Flux Analysis VAP applies a clear-sky detection and fitting technique (Long and Ackerman 2000) to data from broadband SW radiometers located at the Southern Great Plains site. This [more](#)

Get Data View Metadata

Short Wave Flux Analysis: 1-min resolution on SKYAD data, Long algorithm at North Slope Alaska Related Dataset

Data Source: Atmospheric Radiation Measurement Begin Date: 03/31/1999 End Date: 12/31/2014

Federal Agency: Department of Energy

The SW (shortwave) Flux Analysis VAP applies a clear-sky detection and fitting technique (Long and Ackerman 2000) to data from broadband SW radiometers located at the Southern Great Plains site. This [more](#)

Get Data View Metadata

ECOR: surface vertical fluxes of momentum, sensible heat, and latent heat, 30-min avg at North Slope Alaska Related Dataset

Data Source: Atmospheric Radiation Measurement Begin Date: 09/15/2011 End Date: 12/31/2014

Federal Agency: Department of Energy

The eddy correlation (ECOR) flux measurement system provides in situ, half-hour measurements of the surface turbulent fluxes of momentum, sensible heat, latent heat, and carbon dioxide. The fluxes are [more](#)

Get Data View Metadata

Three Meter Tower: video camera at North Slope Alaska Related Dataset

Data Source: Atmospheric Radiation Measurement Begin Date: 03/24/2002 End Date: 01/15/2011

Federal Agency: Department of Energy

The tower camera in Barrow provides hourly images of ground surrounding the tower. These images may be used to determine fractional snow cover as winter arrives, for comparison with the albedo that [more](#)

Get Data View Metadata

Surface Energy Balance System at North Slope Alaska Related Dataset

Data Source: Atmospheric Radiation Measurement Begin Date: 09/12/2011 End Date: 12/31/2014

Federal Agency: Department of Energy

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

