EARTH SCIENCES DIVISION

DOE NGEE – Arctic Land-Atmosphere Interactions

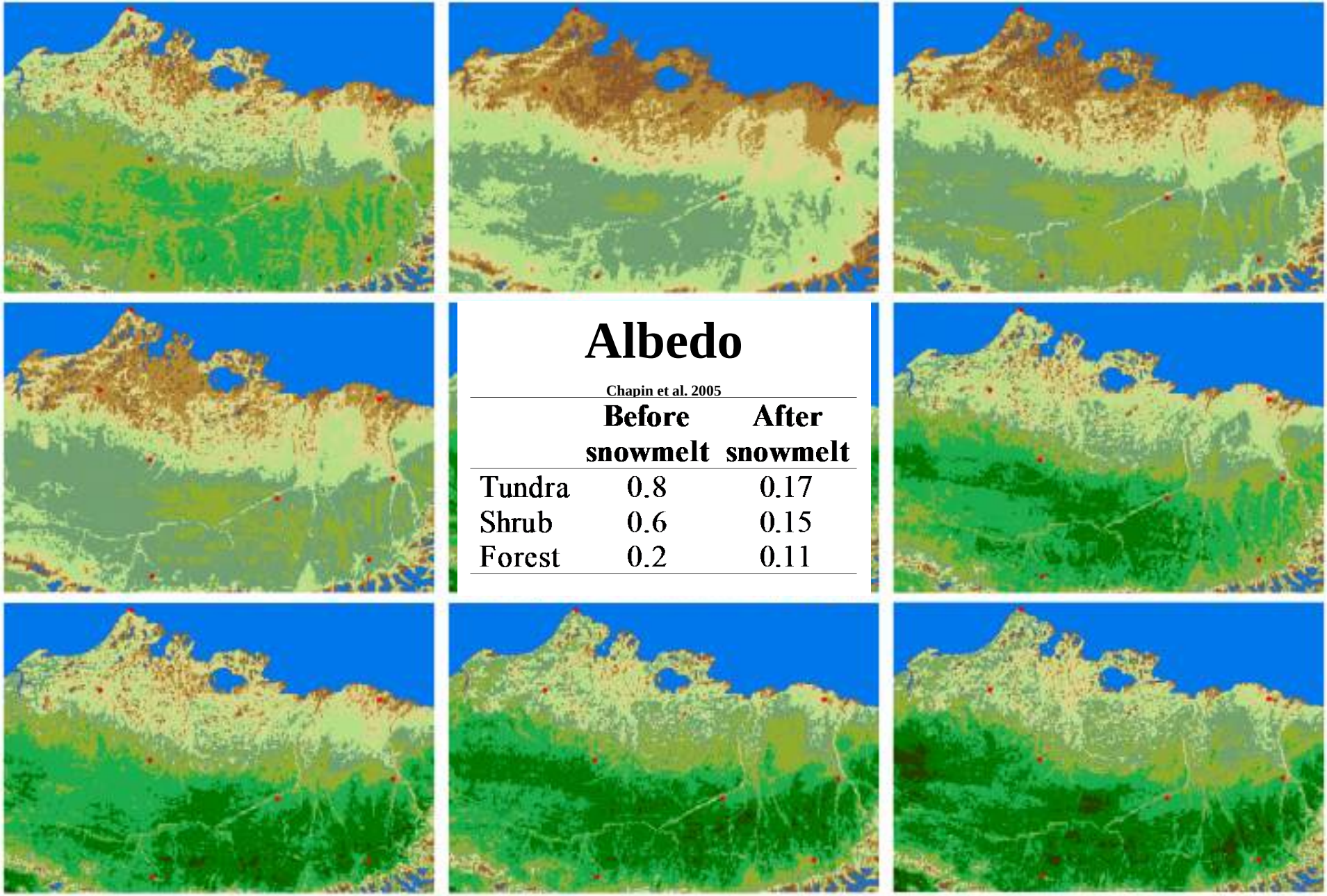
Margaret S. Torn
and the NGEE Arctic Team

ARM/ASR Joint Meeting
Vienna, VA
March 18, 2015

BERKELEY LAB

NGEE Arctic

Lead PI: Stan Wullschleger
Photos by Lydia Smith



Albedo

Chapin et al. 2005

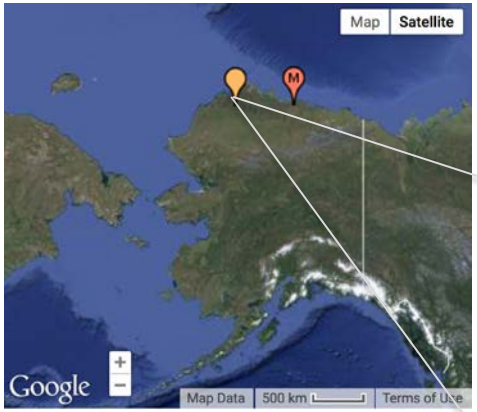
	Before snowmelt	After snowmelt
Tundra	0.8	0.17
Shrub	0.6	0.15
Forest	0.2	0.11

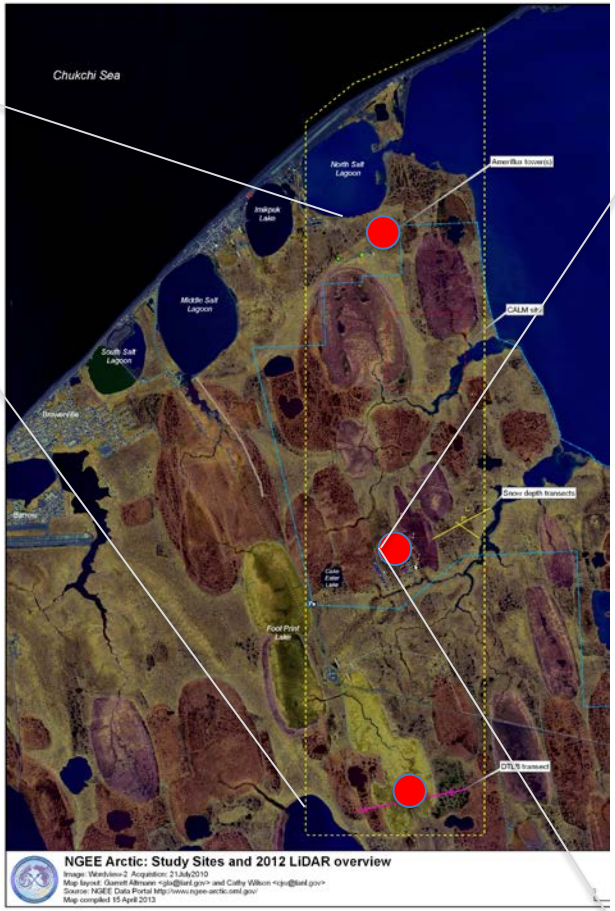
Time Integrated NDVI
Epstein and Walker

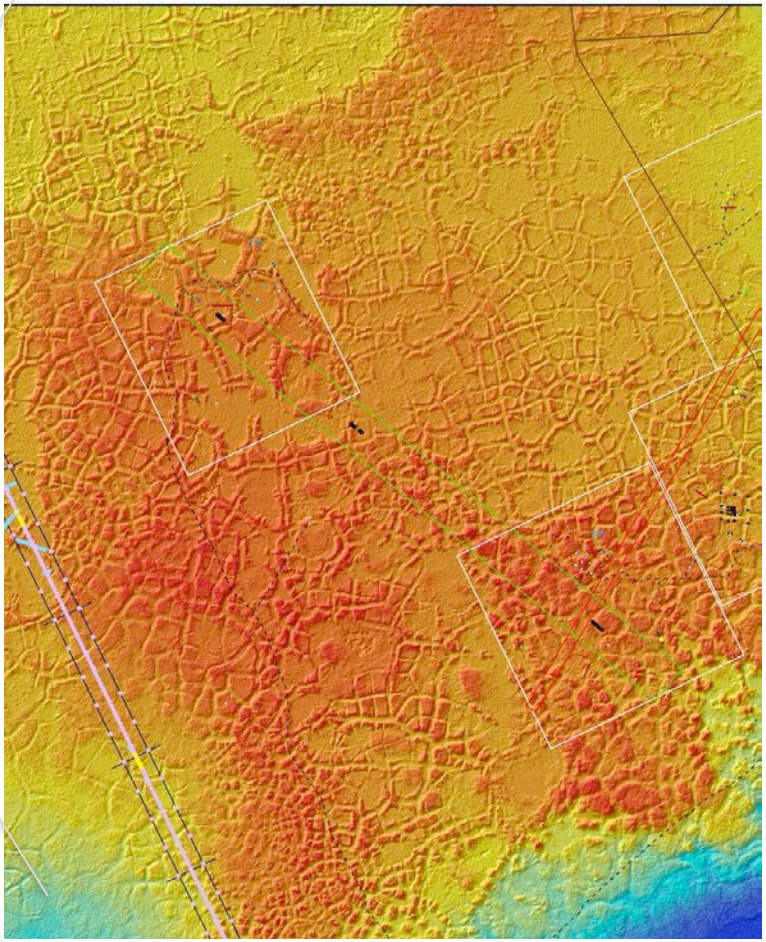
91	92	93
94	95	96
97	98	99

Low ← → High

North Slope of Alaska
Barrow

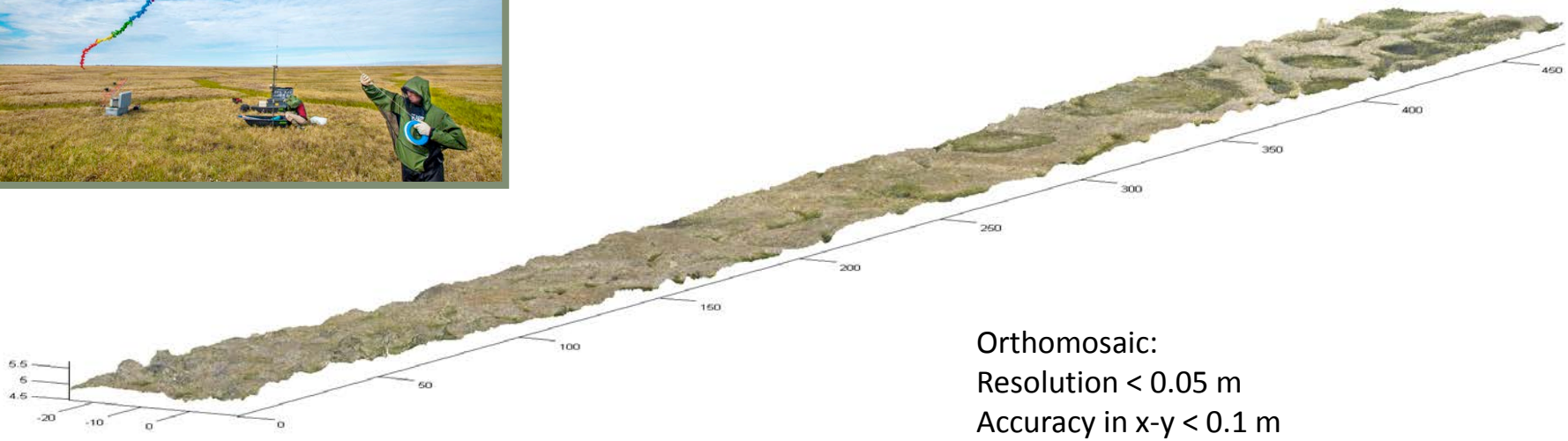






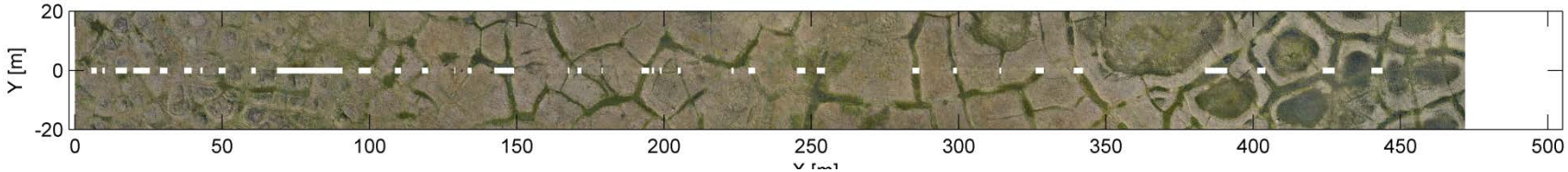
Barrow Environmental Observatory

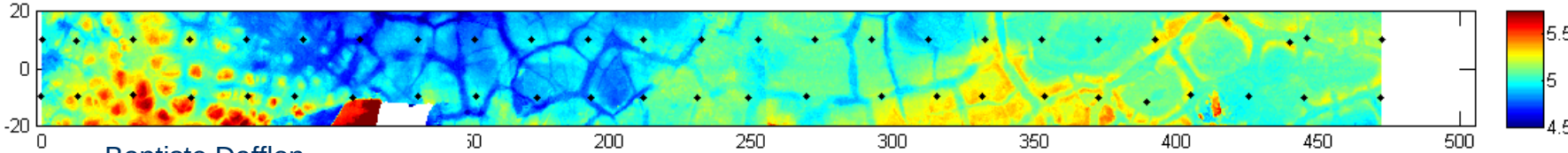
DEM from Kite-based aerial imaging



Orthomosaic:
Resolution < 0.05 m
Accuracy in x-y < 0.1 m

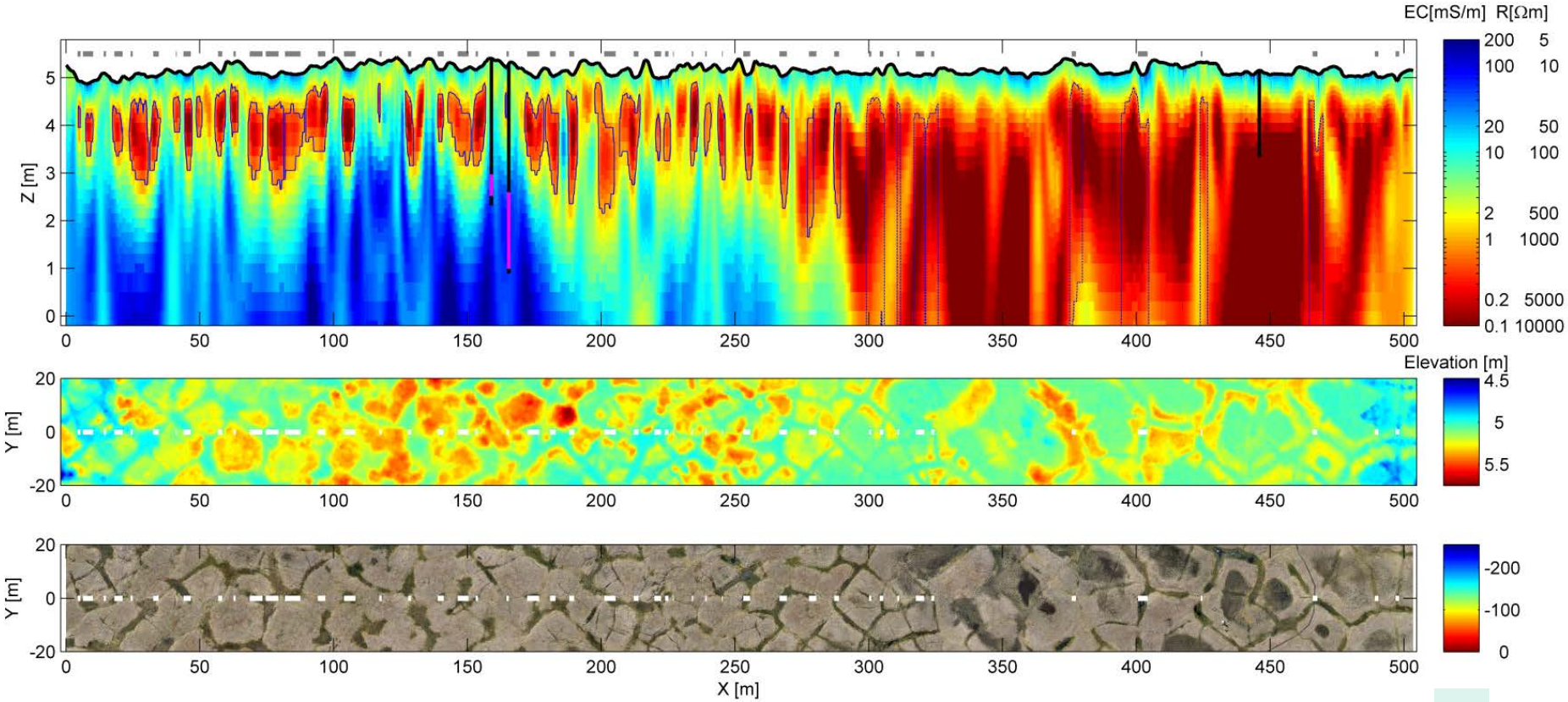
DEM: Accuracy in x-y-z < 0.1 m



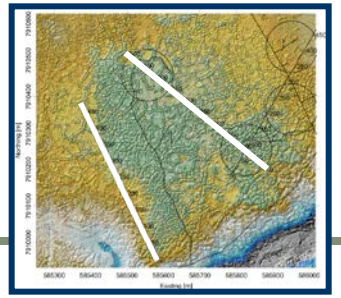


Baptiste Dafflon

Landscape Dynamics: linking subsurface ice and drainage to surface processes

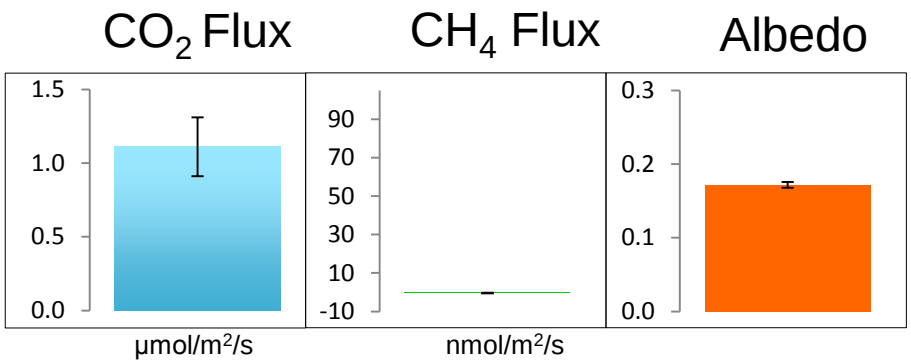


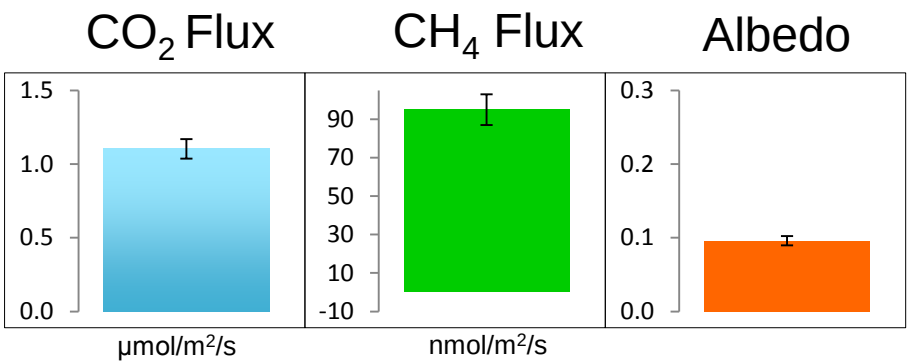
Geophysics:
Electrical resistance tomography,
Ground penetrating radar,
Electromagnetic conductivity,
Ohm Mapper, CT scans,
…



Baptiste Dafflon

Effect of subsurface ice and drainage on climate: Surface CO_2 and CH_4 fluxes, and Albedo

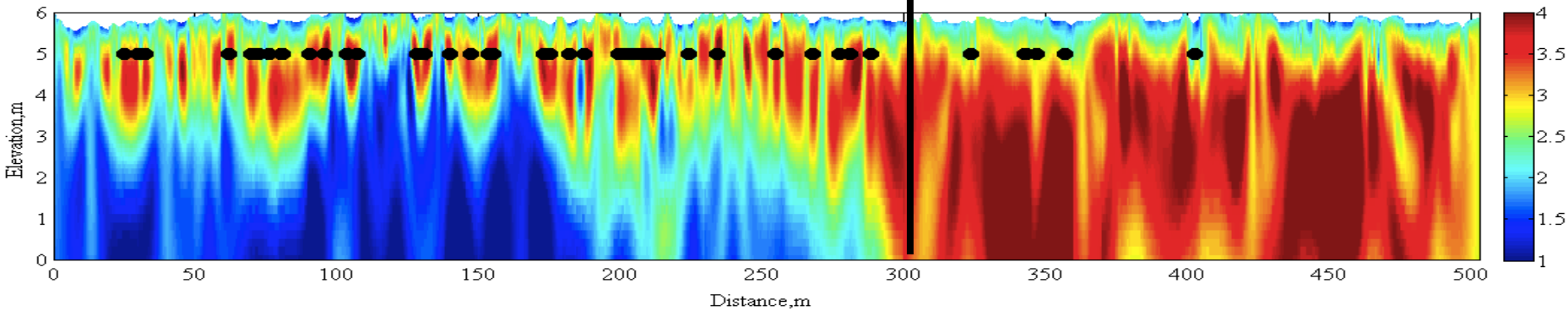




Site 1

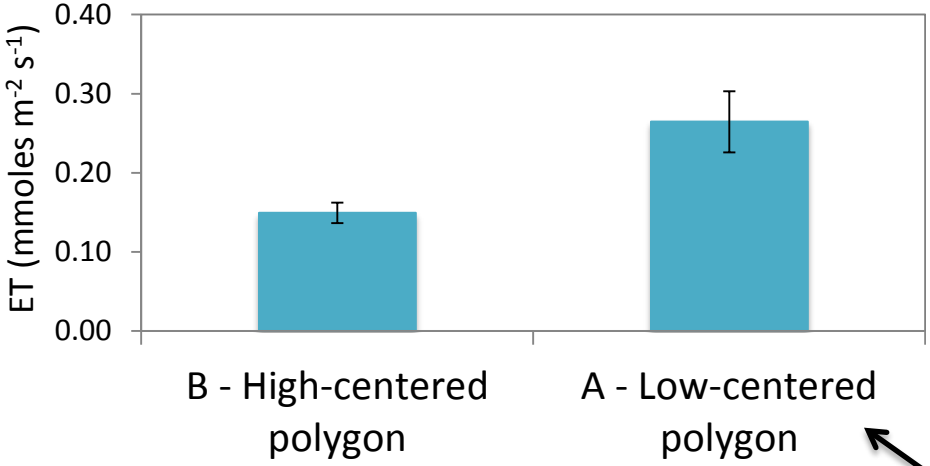
High/Flat Centered Polygons

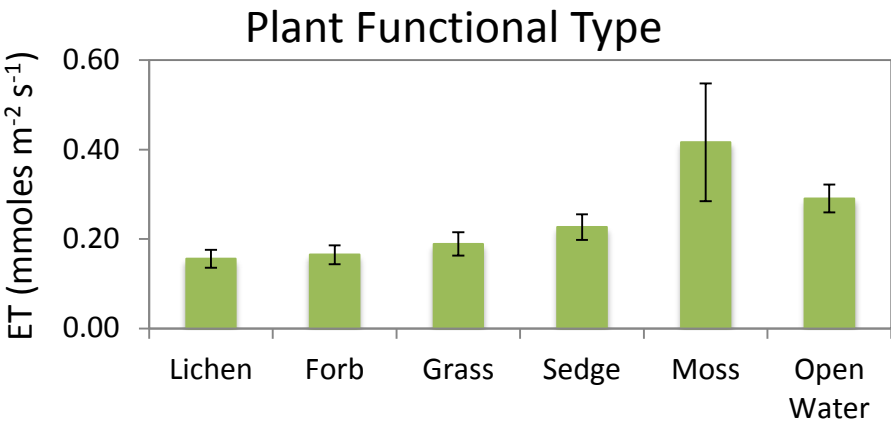
Low Centered Polygons



Wainwright et al 2015; Torn et al.

Effect of subsurface ice and drainage on climate:
Evapotranspiration

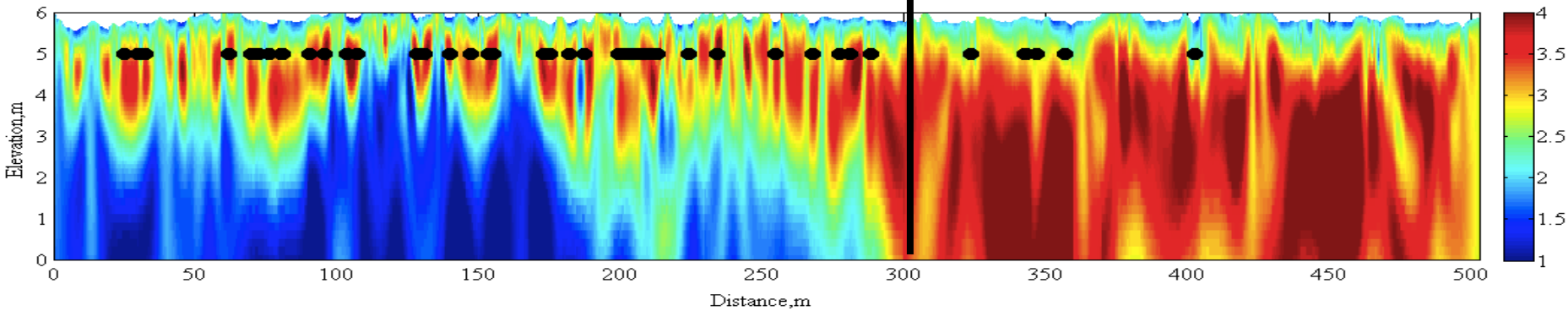




Site 1

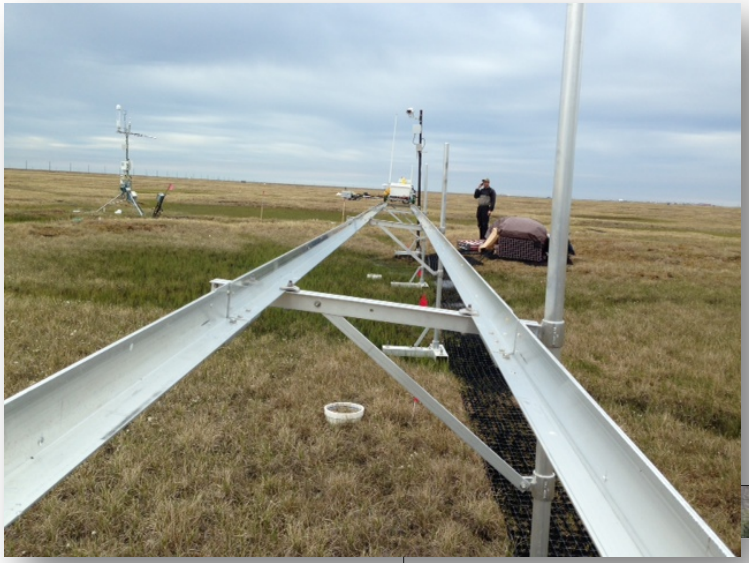
High/Flat Centered Polygons

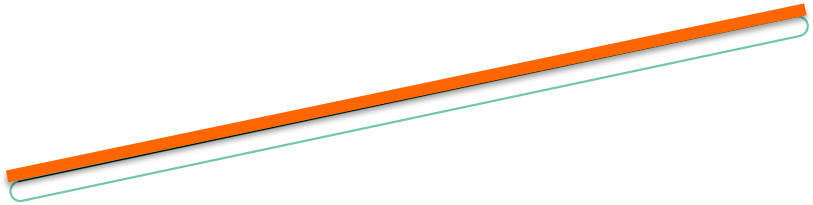
Low Centered Polygons



Raz Yaseef et al. In Prep

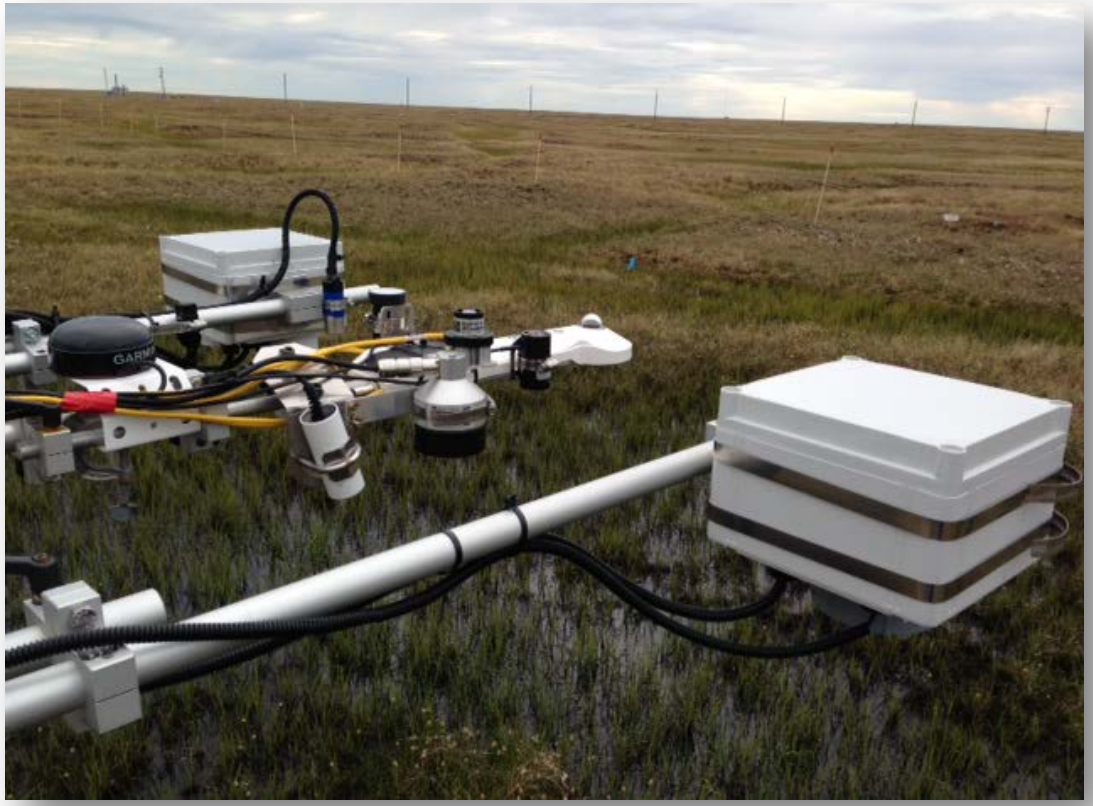
Tram across polygonal tundra

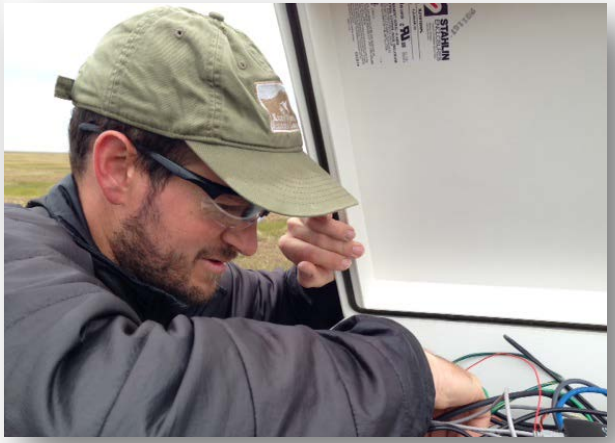




Barrow Environmental Observatory, Barrow, AK

Tram Sensors





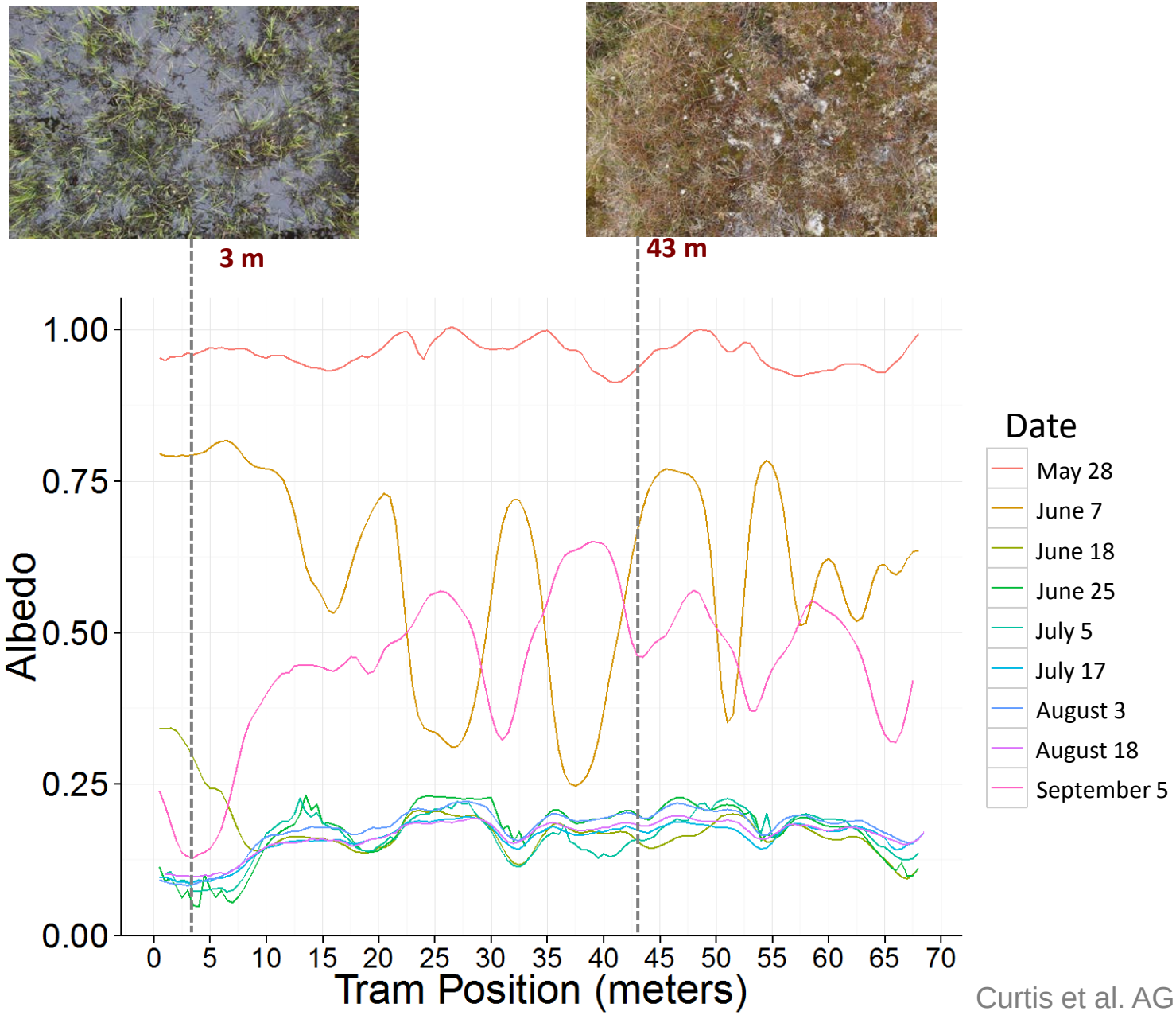
Bryan Curtis

Tram Sensor	Purpose
Net Radiometer	Albedo, LW, SW
IR Surface Temperature	Skin temperature of land surface
PAR, Incident & Reflected	Fraction of absorbed PAR
Spectral Red/NIR, Incident & Reflected	NDVI – Normalized Difference Vegetation Index
Spectroradiometer (310 – 1100 nm)	Near-surface remote sensing
Spectral Camera	High spatial resolution of spectra
Thermal Camera	Spatial distribution of surface temperature
Sonic Distance Sensor	Snow and water depth
Digital RGB Camera	Photo of sensor footprint

Subsurface: Soil Moisture and Temp, Geophysics

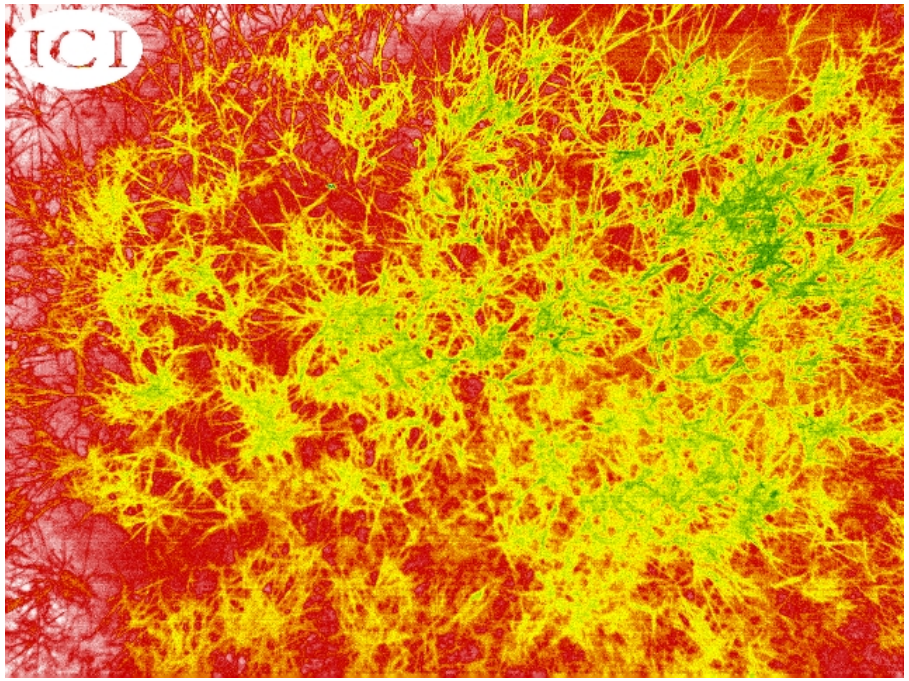
* PAR = photosynthetically active radiation

Tram Albedo



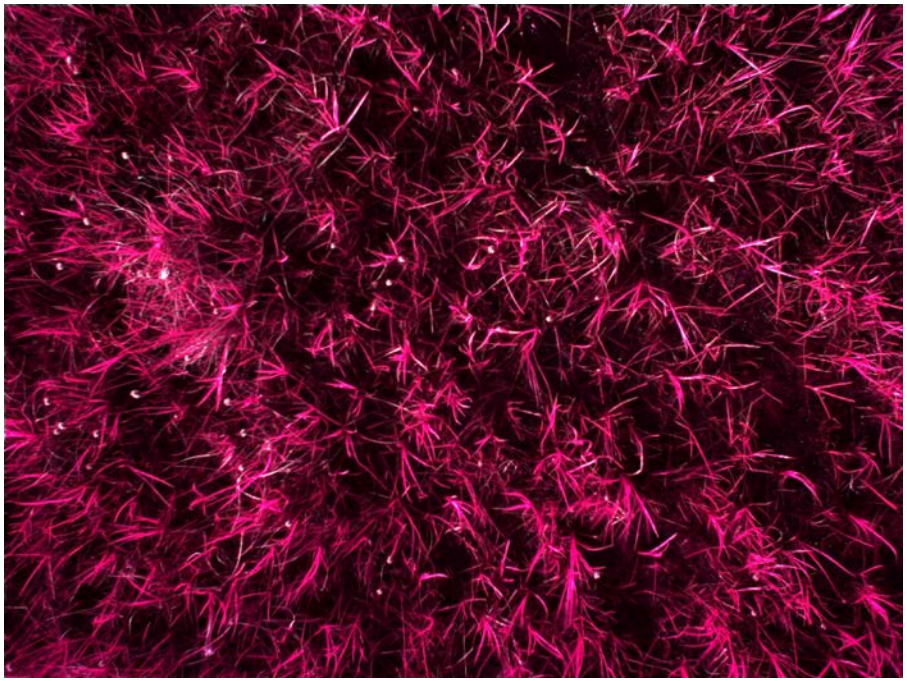
Curtis et al. AGU 2014

Thermal Imagery



Skin temperature of vegetation and surface taken with tram's thermal camera. Temperature scales from coolest to warmest: green < yellow < red < white.

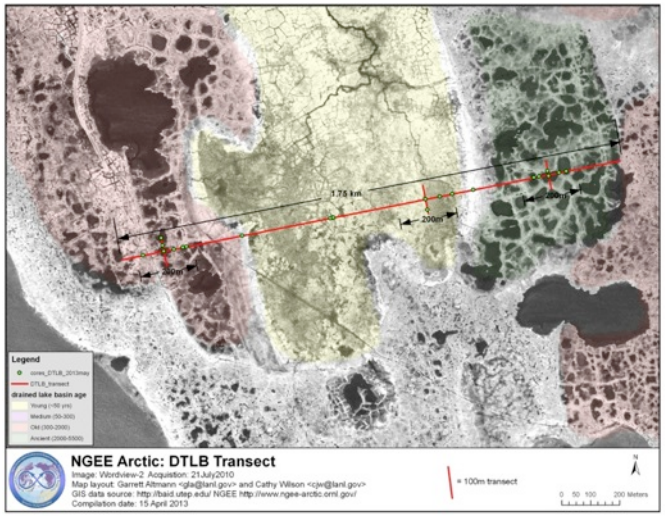
Spectral Imagery



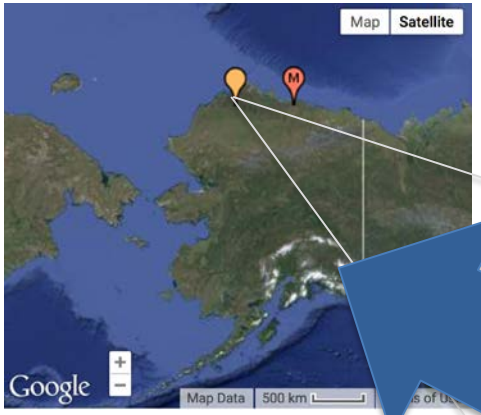
False color composite of red, green, and near infrared spectral bands. Bright color pixels show high chlorophyll reflectance (NDVI).

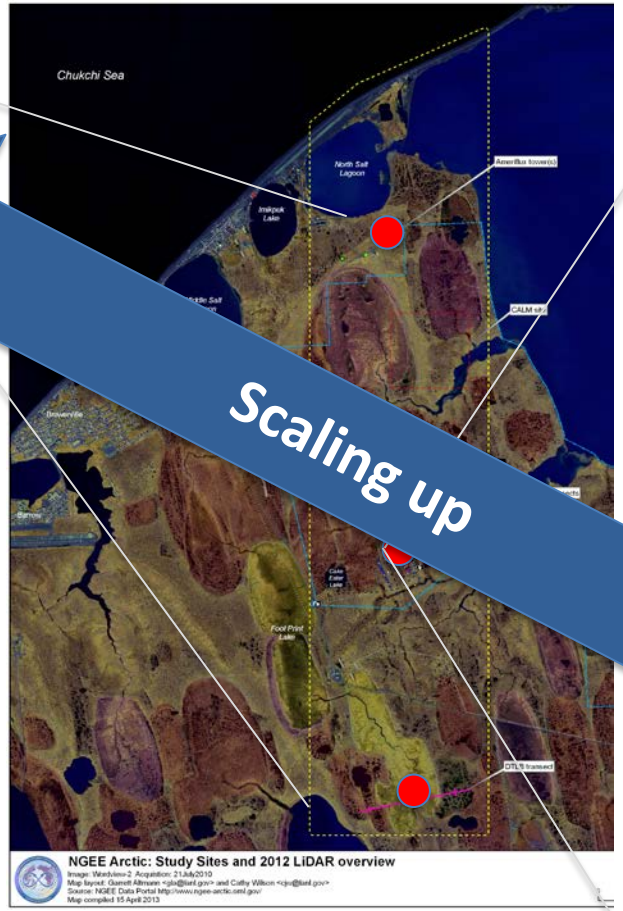
PEP: The portable energy pole

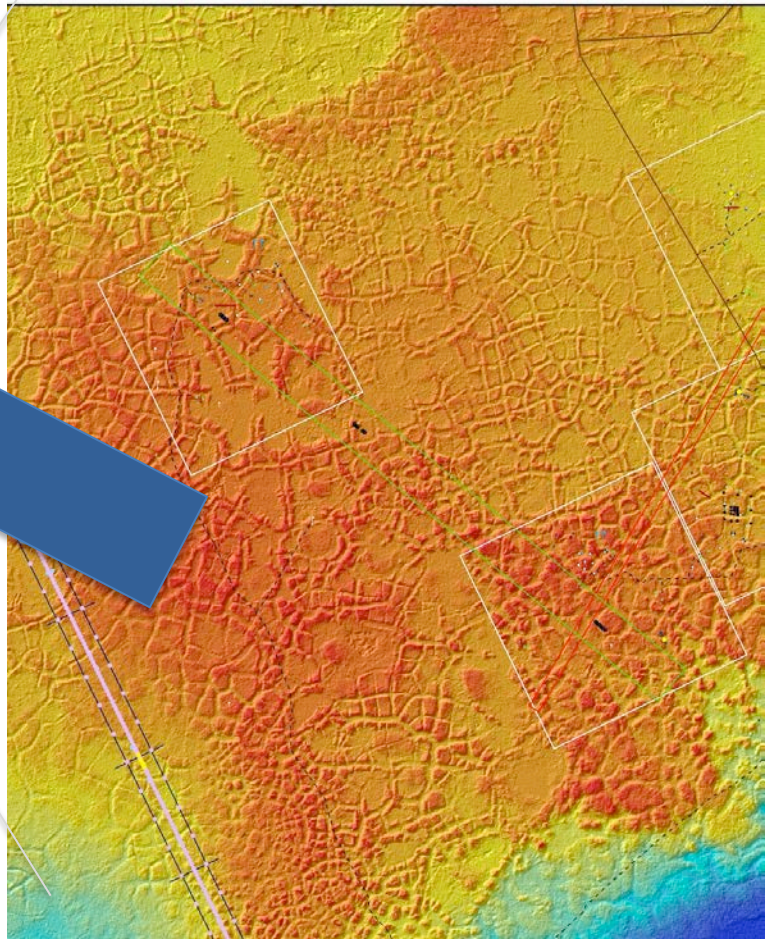
Tram sensors on a stick!



North Slope of Alaska
Barrow

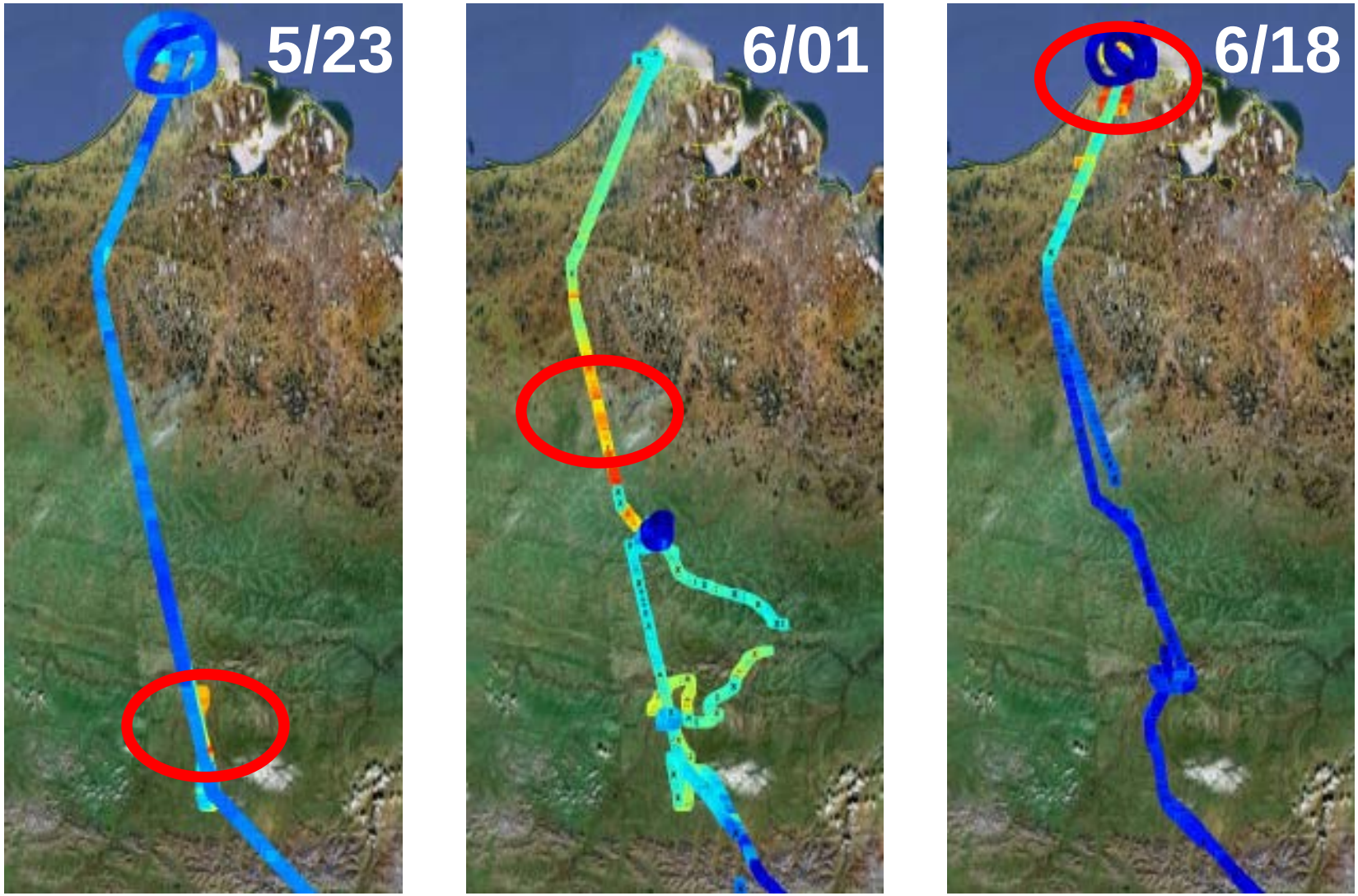






Scaling up

NASA CARVE observes spring CH4 release across the North Slope



Courtesy of Charles Miller and CARVE Team

Conclusions

- **Subsurface (permafrost, ice content) influences surface forcing via its impact on geomorphology, vegetation, and soil moisture.**
- **Tram sensors measure surface properties useful for ARM analyses (e.g., albedo, spatial statistics).**
- **Tram data enable scaling from polygon feature to tower footprint, grid cell, or aircraft/satellite.**
- **Opportunity for collaboration with ARM/ASR (IOP proposal in prep)**

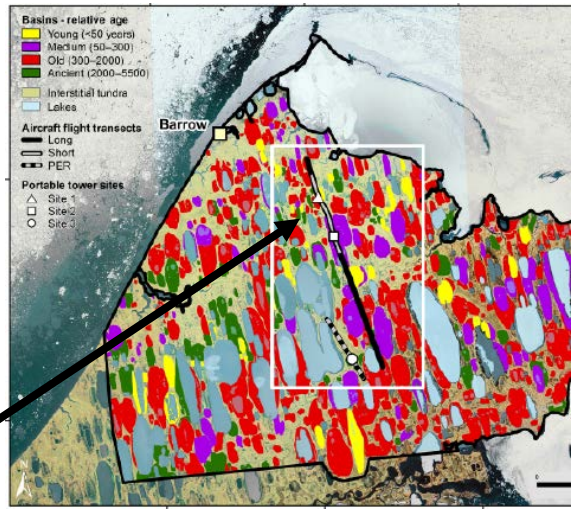
NGEE Arctic

Lead PI: Stan Wullschleger
Photos by Lydia Smith

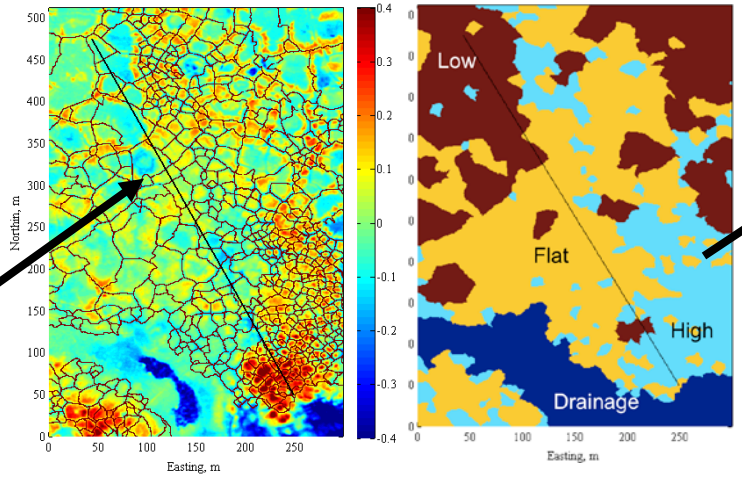
Model-Data scaling strategy: *geomorphic units*

Hierarchical Landscape Classification
- Combine multiple datasets (e.g., remote sensing, geophysics)
- Statistical clustering/classification

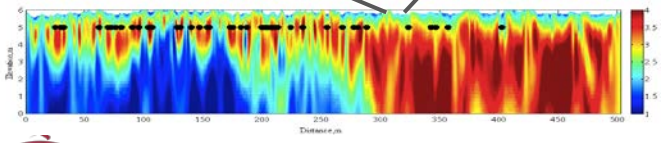
Regional Scale



Site Scale: Polygon Types



Polygon Scale



Subsurface-surface properties co-vary and are spatially clustered.
→ Zonation approach for distributing properties and scaling observations to grid cell for model evaluation

Wainwright et al. JGR-B 2015

Changes in Arctic vegetation amplify high-latitude warming through the greenhouse effect

Abigail L. Swann[a,1], Inez Y. Fung[a], Samuel Levis[b], Gordon B. Bonan[b], and Scott C. Doney[c]

PNAS

2010

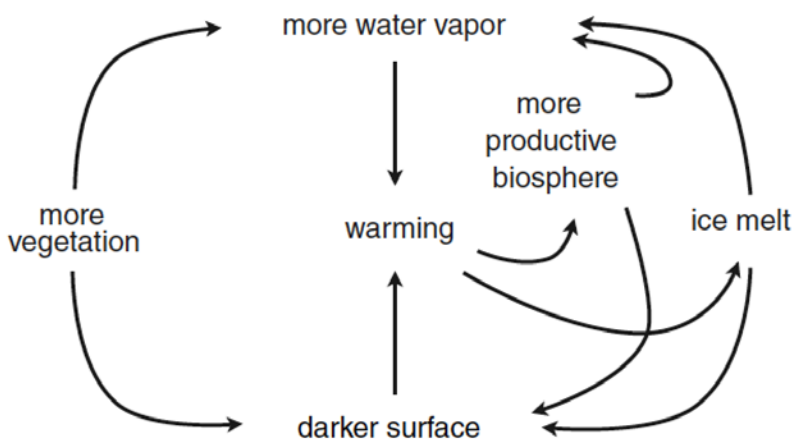


Fig. 5. Diagram representing the response and feedback of vegetation and sea-ice processes on climate at high-northern latitudes.

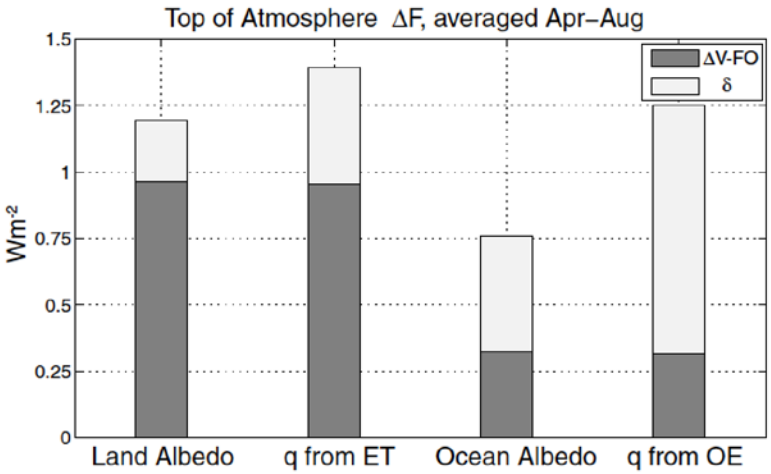


Fig. 4. The top-of-atmosphere net radiative imbalance (ΔF) caused by adding trees. Terms shown (from *Left* to *Right*) are ΔF due to changes in land albedo, water vapor changes from evapo-transpiration (ET), ocean albedo, water vapor changes from ocean evaporation (OE). The total value of each column shows the full ΔF from ΔV – IO. The dark color shows the direct response of ΔV-FO and the light color shows the additional feedback δ(ΔV – IO-ΔV-FO) when the ocean and sea-ice are allowed to respond.