Multiscale Arctic Landscape Characterization

Forrest M. Hoffman[†], Joel Rowland[‡], Jitendra Kumar[†], and Cathy Wilson[‡]

[†]Oak Ridge National Laboratory and [‡]Los Alamos National Laboratories

April 10, 2013

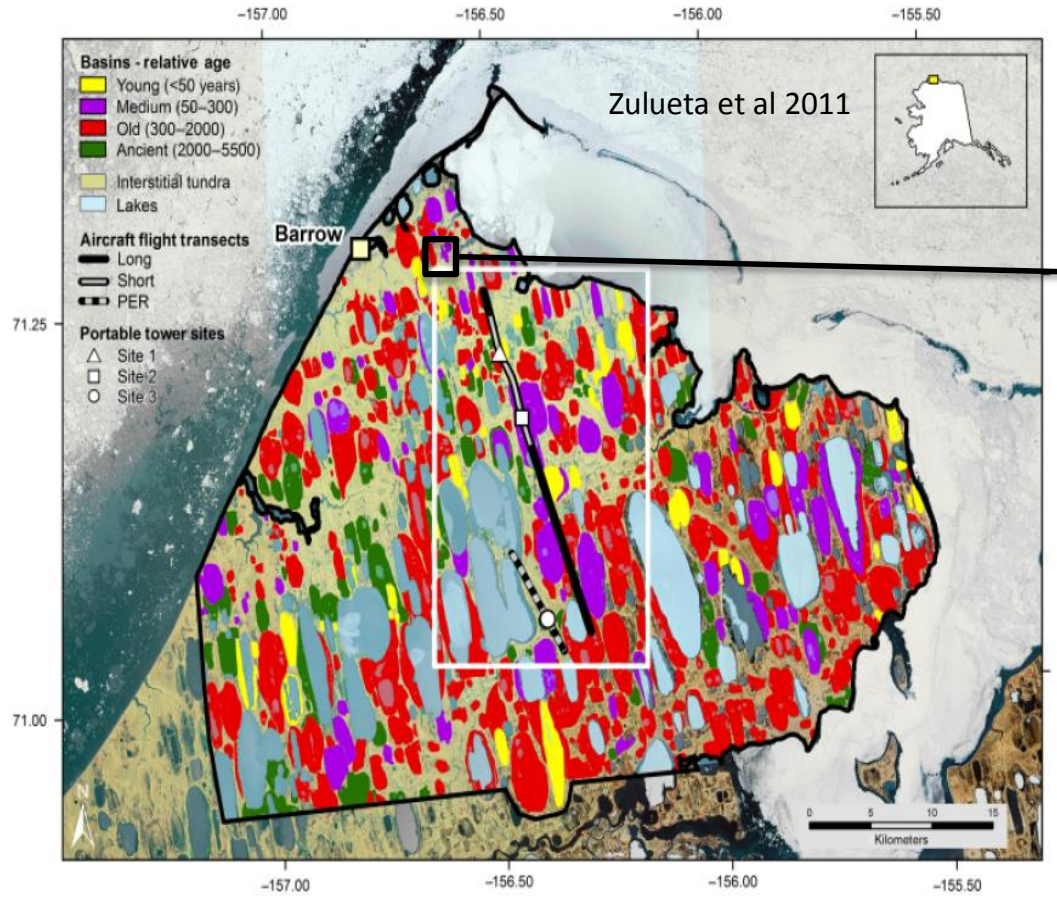
NGEE Arctic Scaling Workshop

Oak Ridge National Laboratory, Oak Ridge, TN 37831 USA

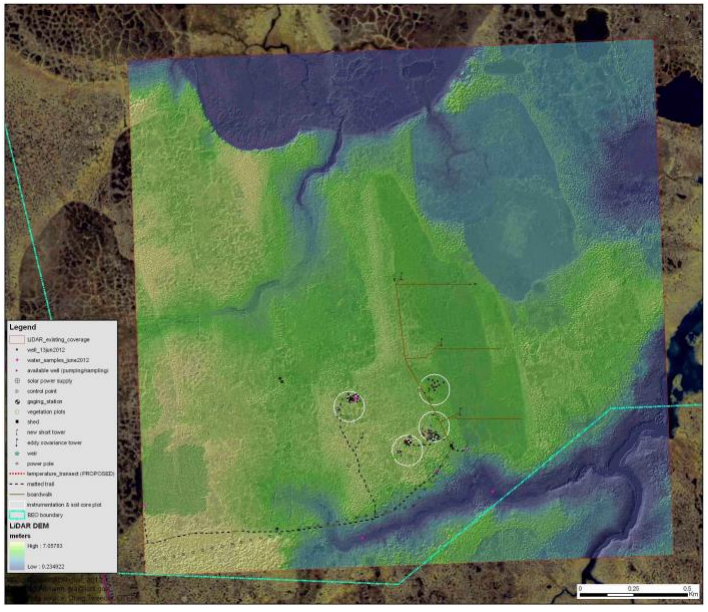
U.S. DEPARTMENT OF ENERGY

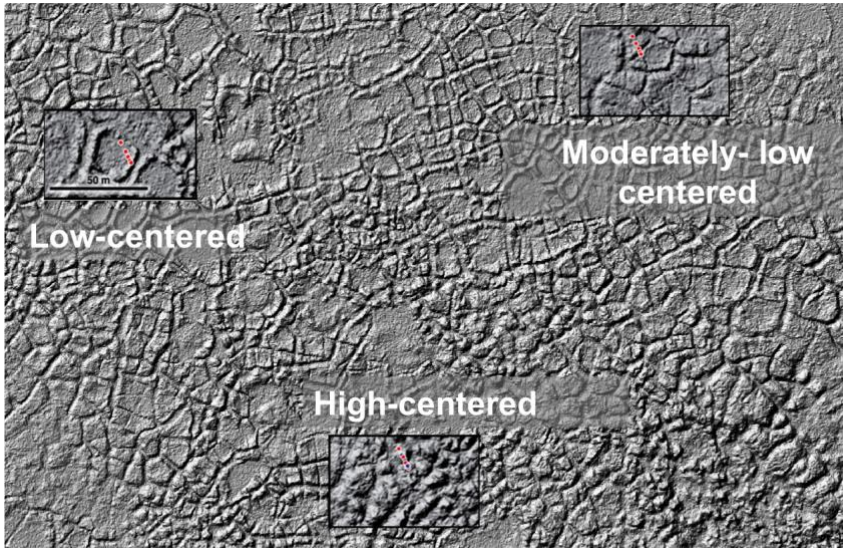
Classify, assign properties to, and parameterize processes across the Arctic landscape

Bio-hydro-geomorphic units
Lakes, Drained Thaw Lake Basins, Interstitial Areas

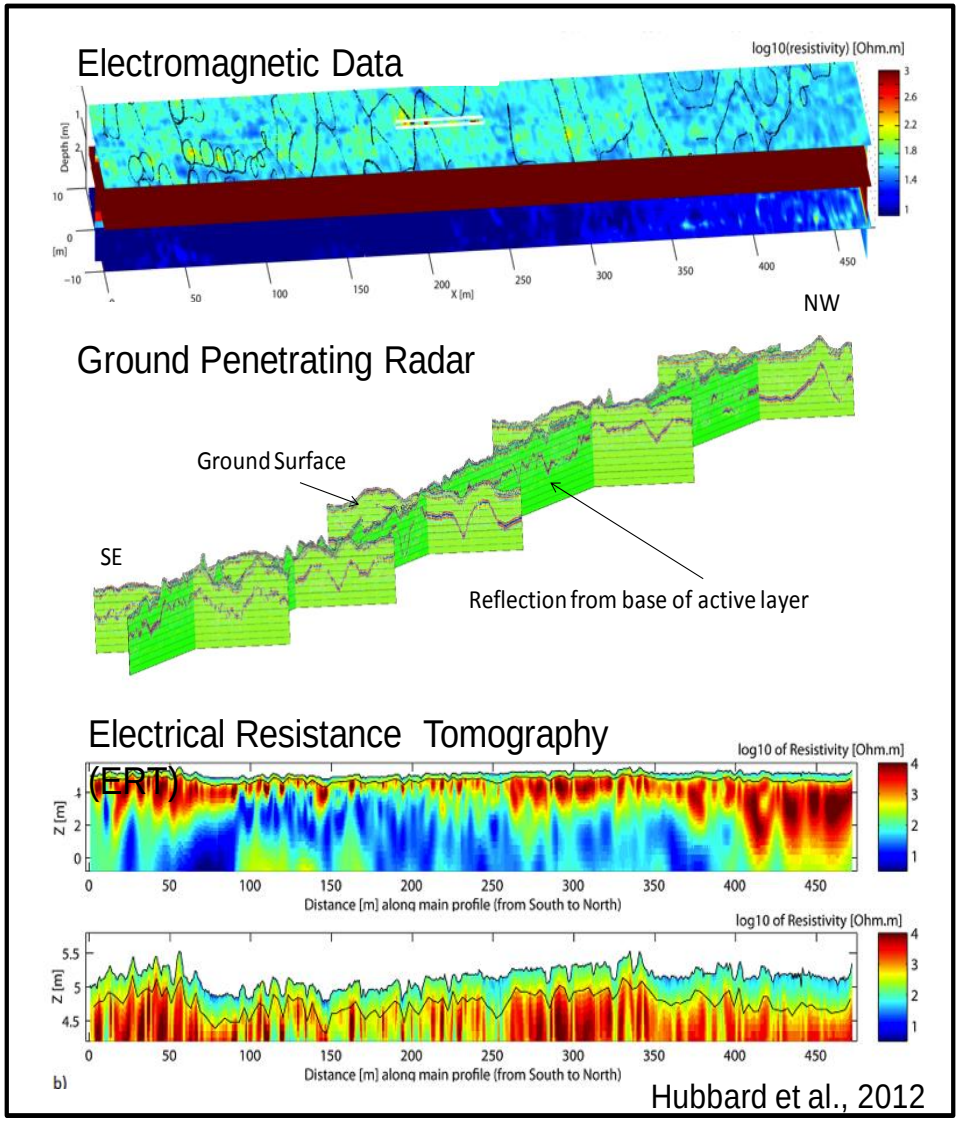


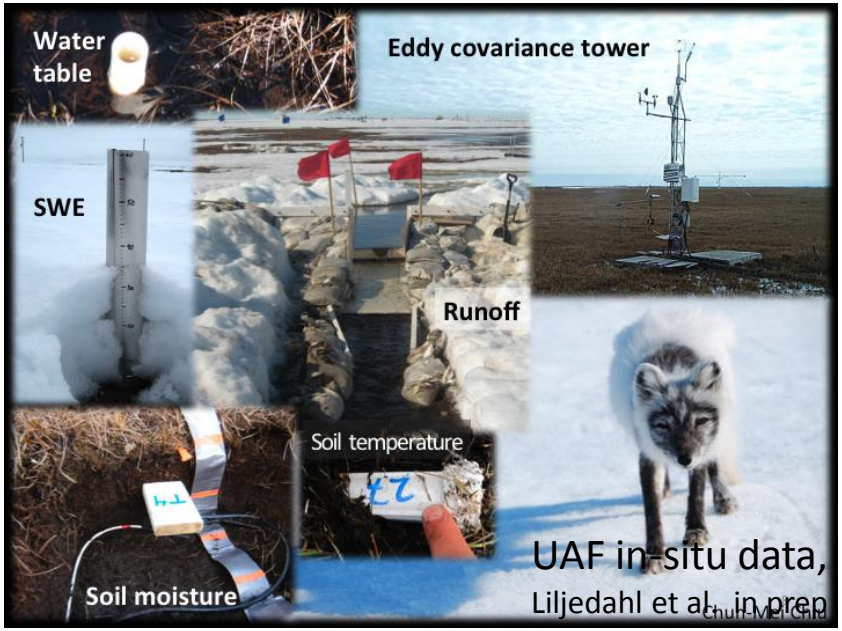
Polygons, channels, other features



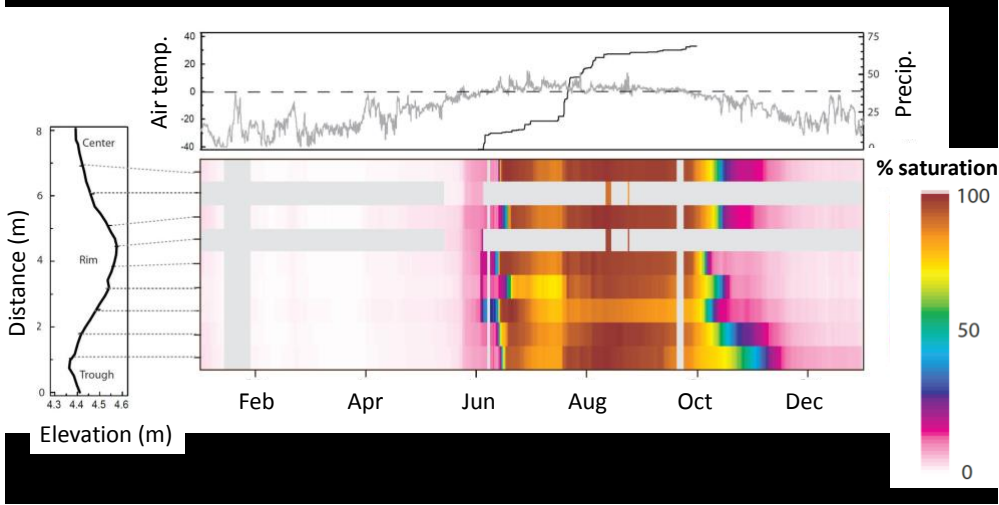


Synthesize in-situ and geophysical data with LiDAR and high res satellite data

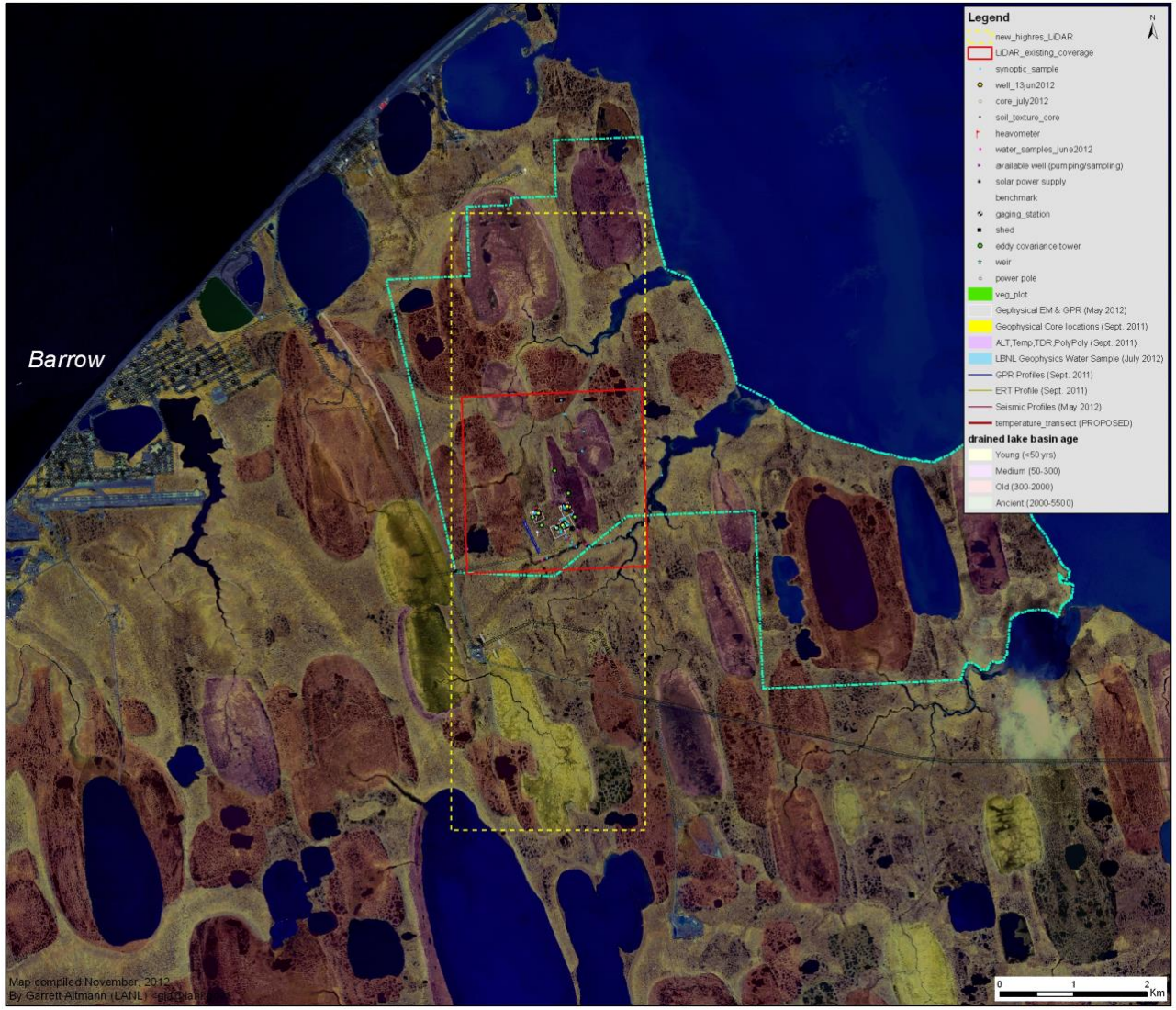




Liquid water content at 7-10 cm depth:
Variations across an 8 m transect @ site C

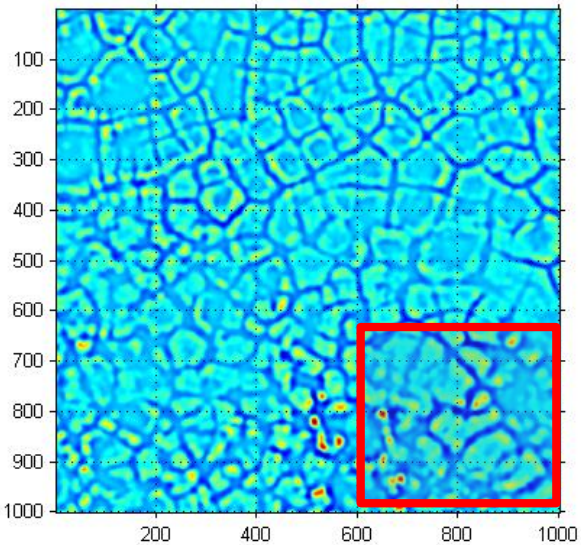


Develop methods to enable the spatial and temporal distribution and evaluation of key properties and processes- Spatial distribution of polygon types and properties from LiDAR and regional multi-spectral data

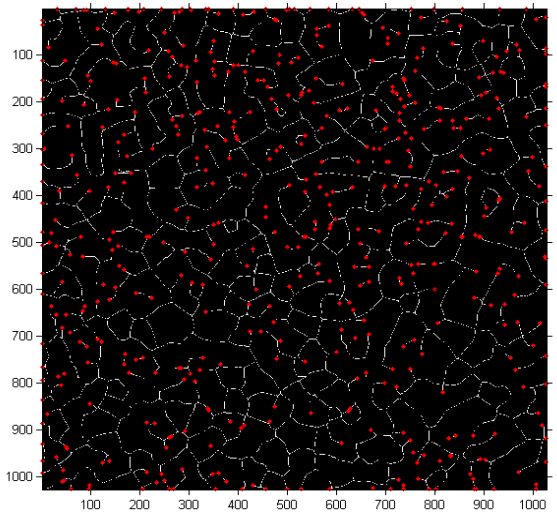


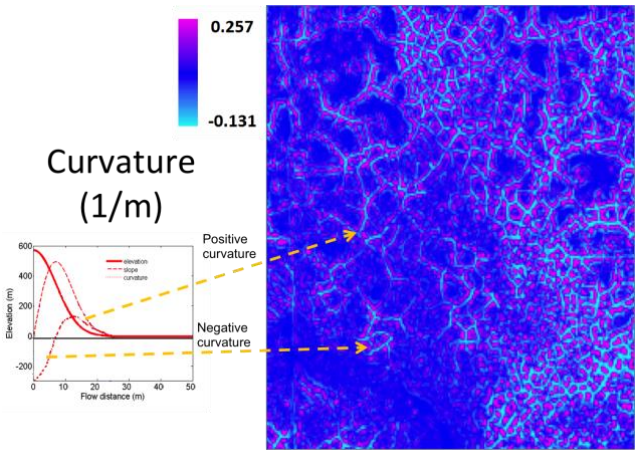
Spatial distribution of polygon types and properties using LiDAR

Gangodagamage et al. in prep

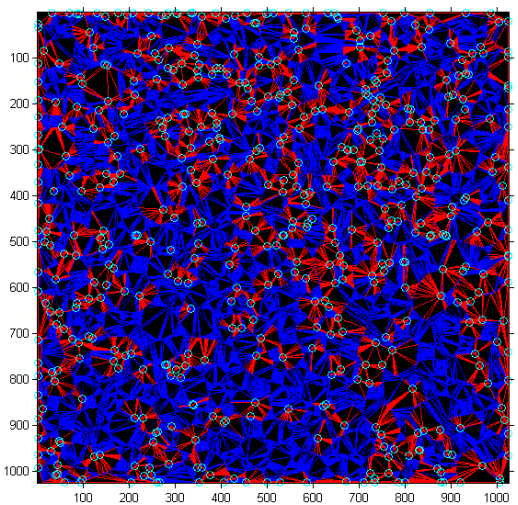


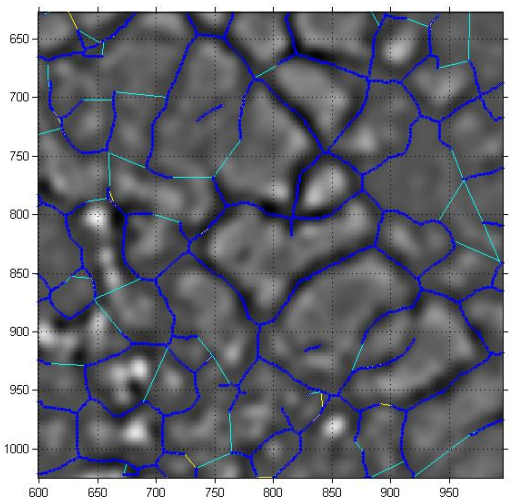
Optimized wavelet transformed LIDAR data

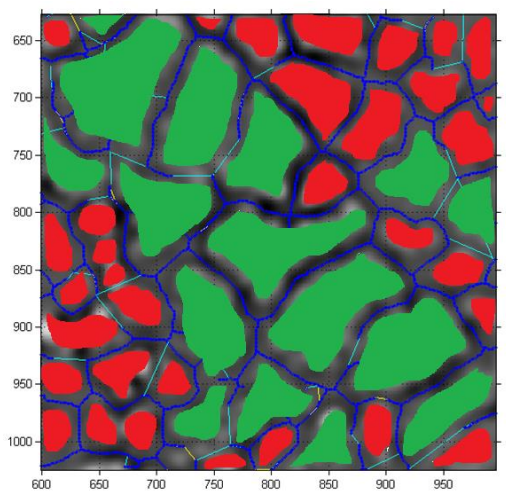




Use values of geomorphic properties to identify poly boundaries and poly types



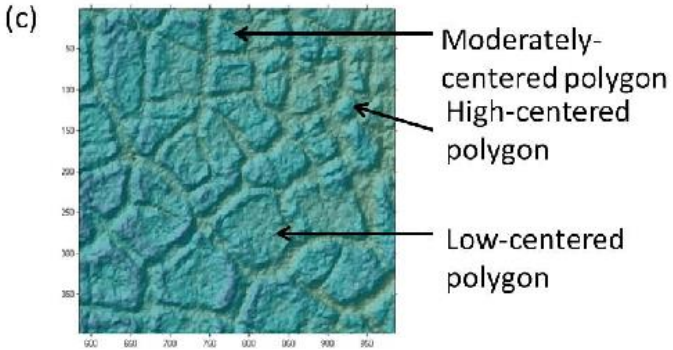


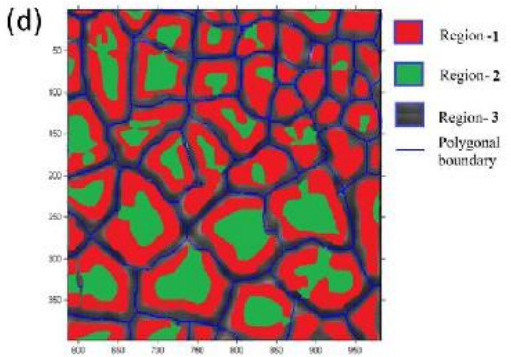


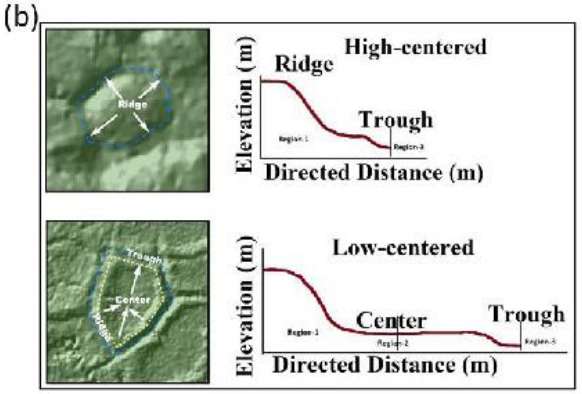
Close polygons using triangulation, redundant edge removal and edge connection

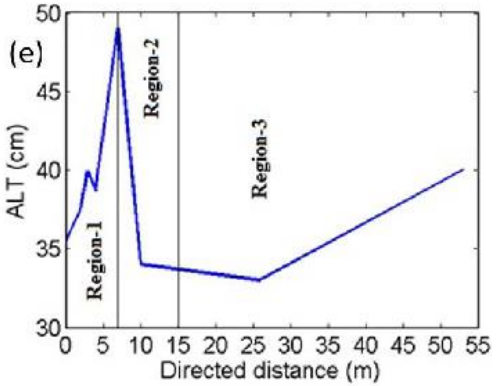
Data assimilation for model domain classification and characterization

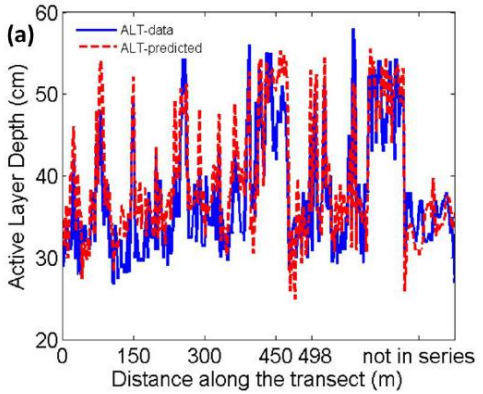
Gangodagamage et al. submitted

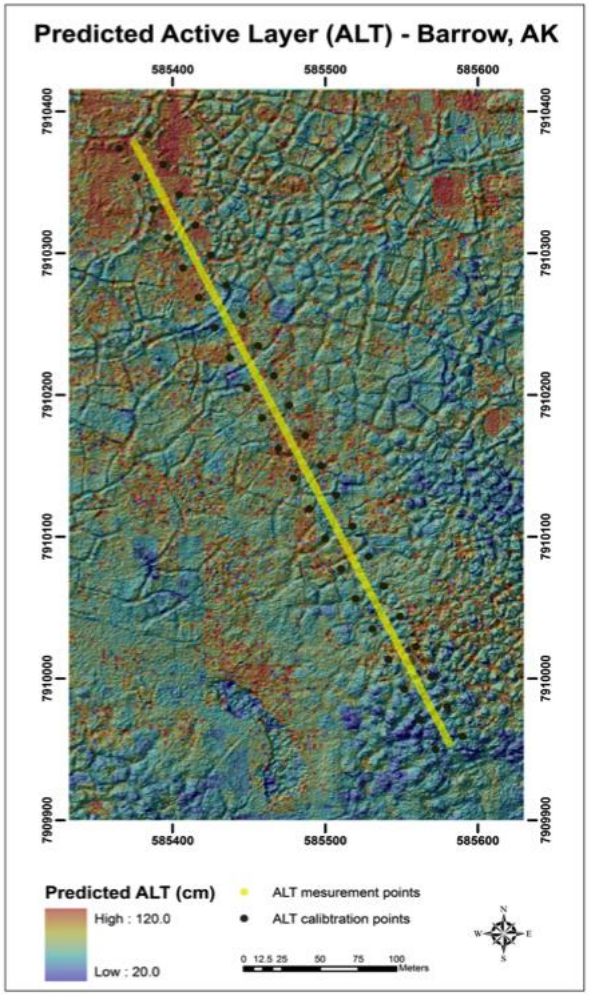






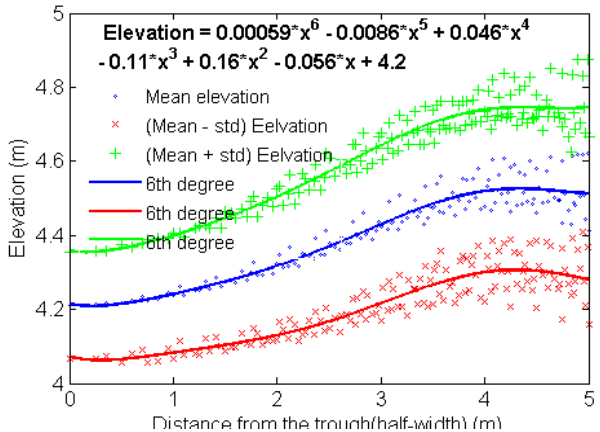


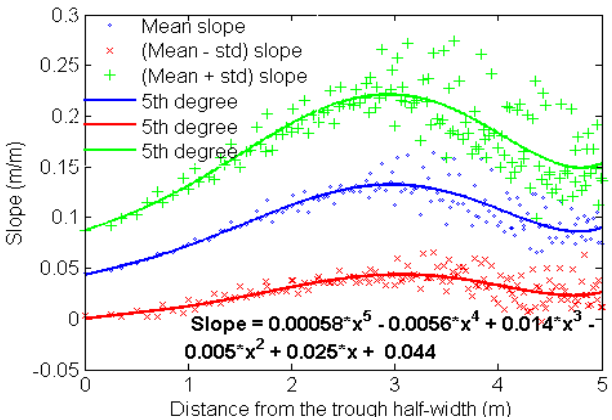


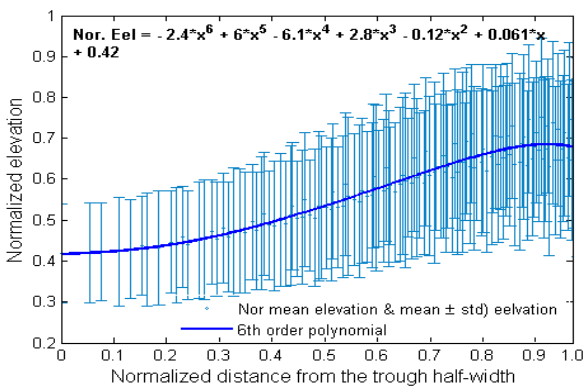


Creating grids from Polygonal ground characteristics

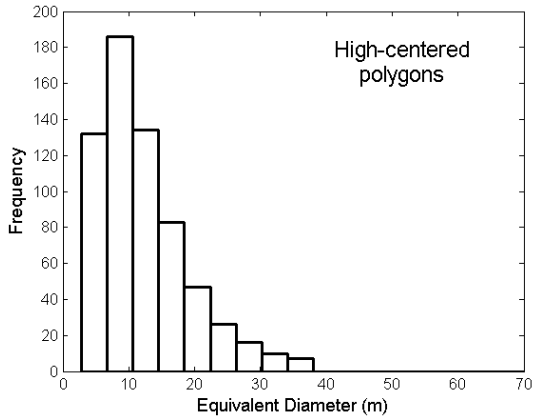
Topographic statistics

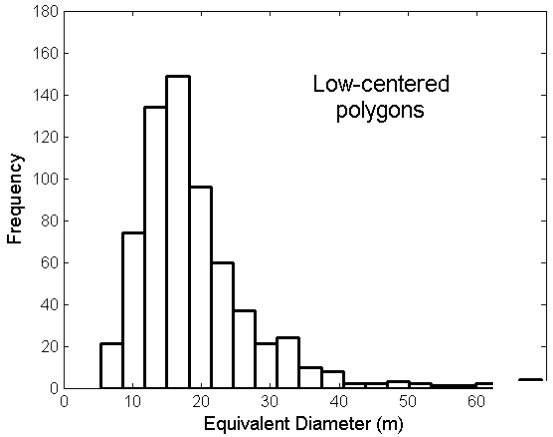


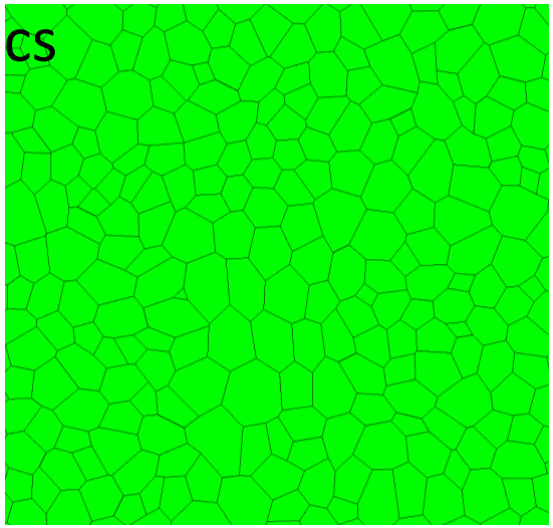


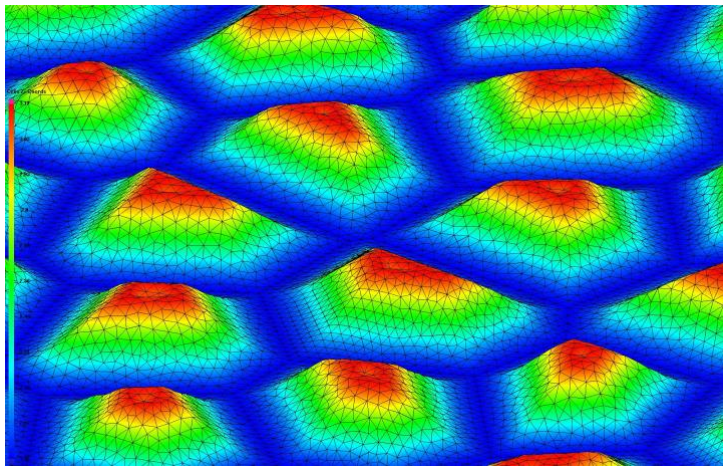


Size/geometry statistics

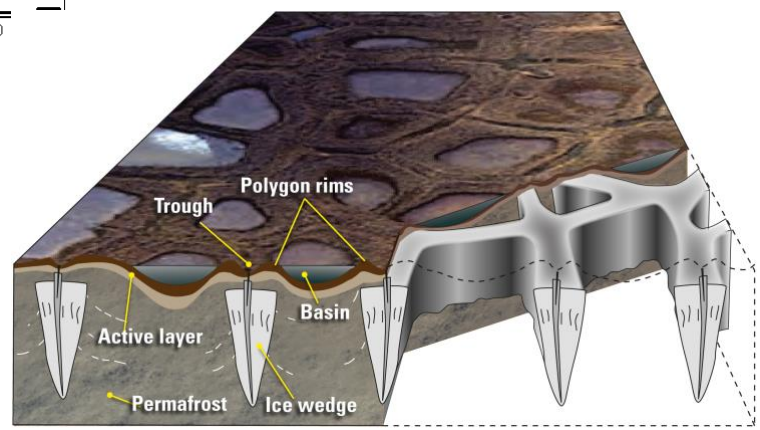








Coming soon: Subsurface statistics with Hubbard et al.



Spatial distribution of polygon types and properties from regional multi-spectral data (Skurikhin et al in prep)

Segmentation of water bodies including ice wedges, troughs, pond-like polygons, lakes, rivers, by Unsupervised Clustering and Level Sets

Original Image (WorldView-2)

©DigitalGlobe; true color image composed of Red, Green and Blue bands; 1,000 x 1,1000 pixels.

- **8 original bands:**
  - Coastal Blue (400-450 nm)
  - Blue (450-510 nm)
  - Green (510-580 nm)
  - Yellow (585-625 nm)
  - Red (630-690 nm)
  - Red-Edge (705-745 nm)
  - NIR1 (770-895 nm)
  - NIR2 (860-1040 nm)
- **2 feature maps:**
  - NDVI = (NIRs-Red)/(NIR1+Red)
  - NDWI = (CoastalBlue-NIR2)/(CoastalBlue+NIR2)

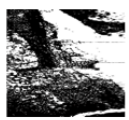
k-means clustering of 8 bands + 2 feature maps to produce seed "water-like"-regions

Extract seeds, candidate "water-like"-regions, to initialize segmentation

Compute additional feature map to perform segmentation

multi-scale wavelets filtering of Red-Edge band to produce energy-based feature map

Segmentation by Level Set Evolution



Segmented "water-like" regions shown in white

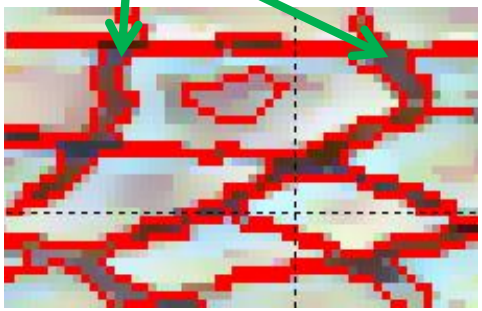
Segmented “water-like” regions

True color (RGB) image

White color for:
ice wedges, troughs, pond-like polygons, lakes and river

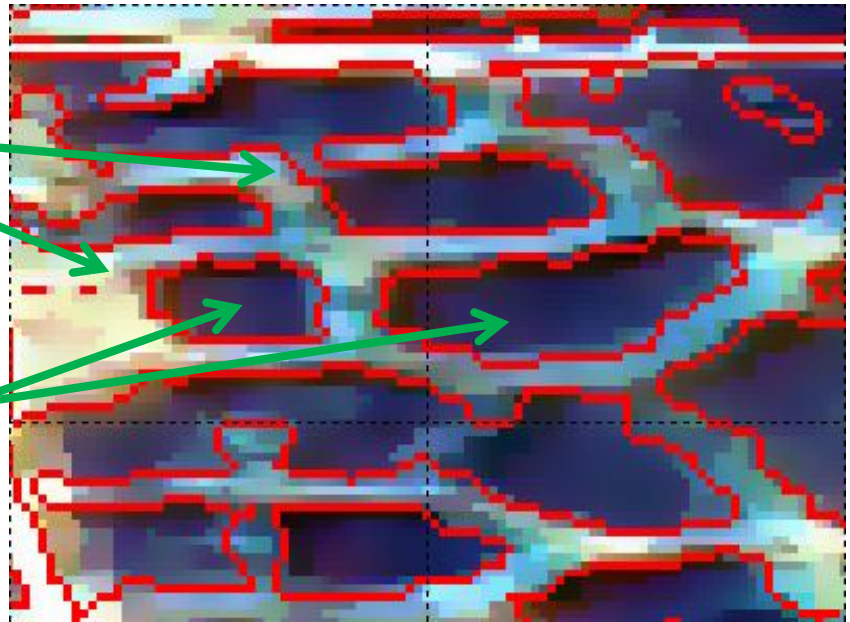
Illustration of the segmentation results:
Contours (in red) outlining boundaries between foreground and background

troughs



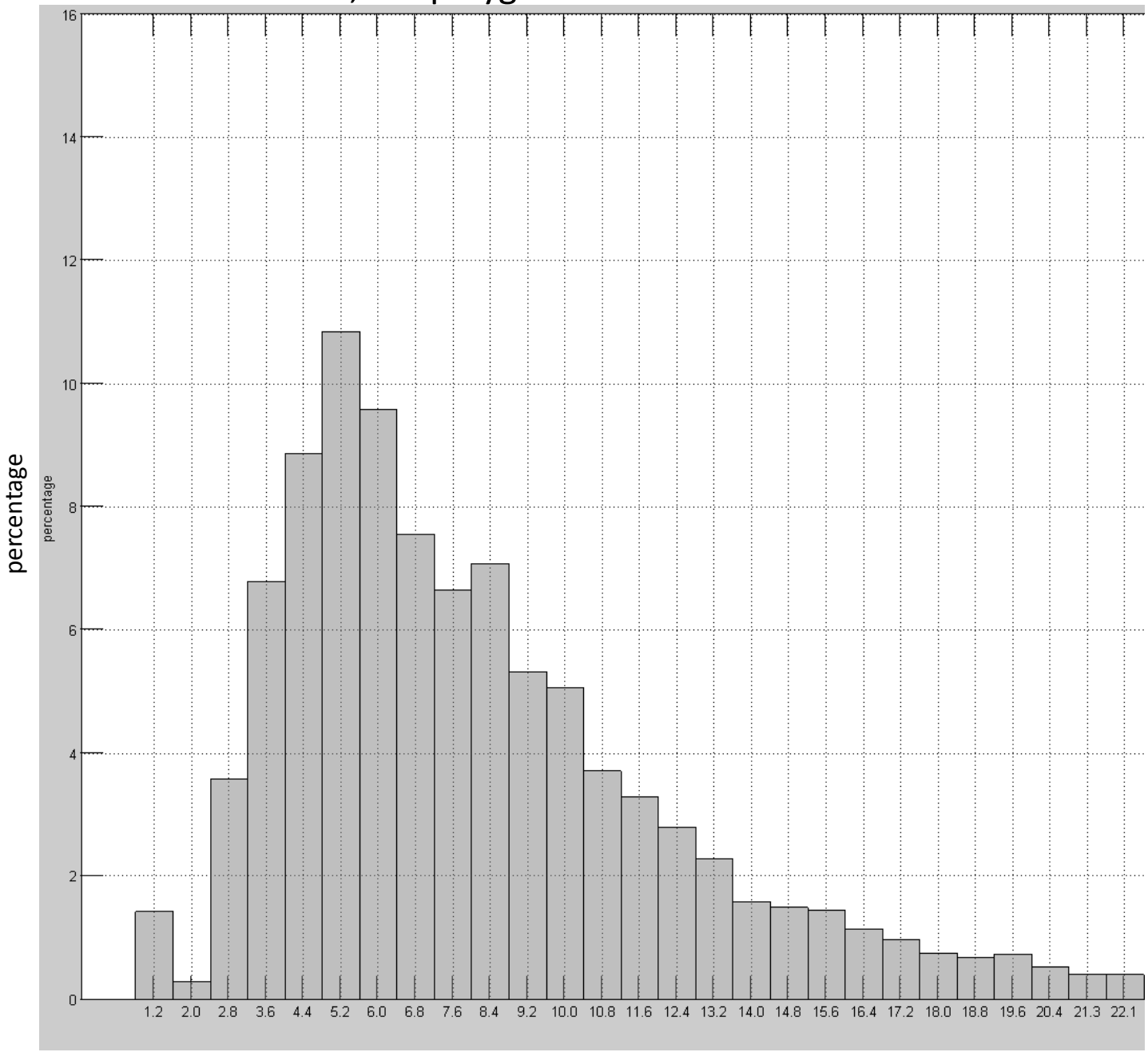
ridges

Polygon-ponds

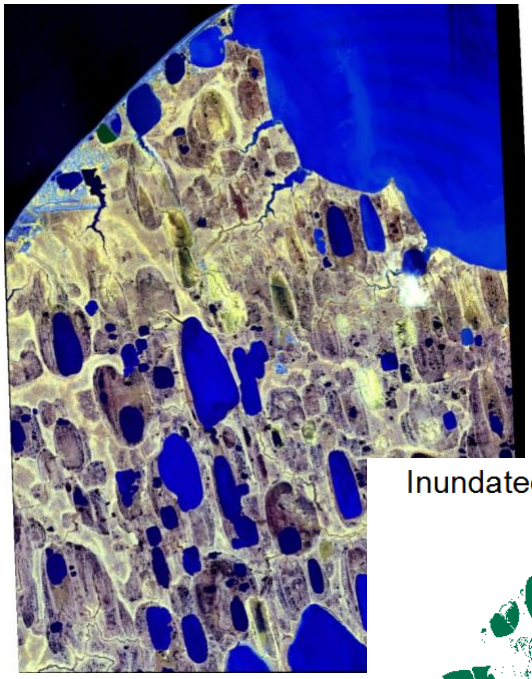


Histogram of Equivalent Diameter

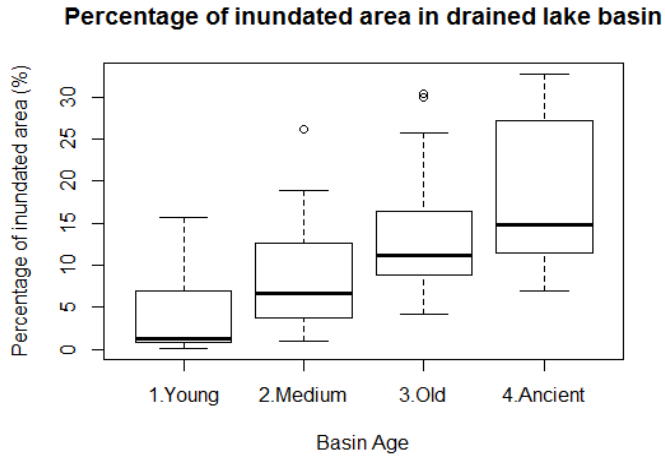
6,134 polygons. Bin Size = 0.8 meter



Evaluation data sets: dynamic spatial distribution of standing water to evaluate model predictions

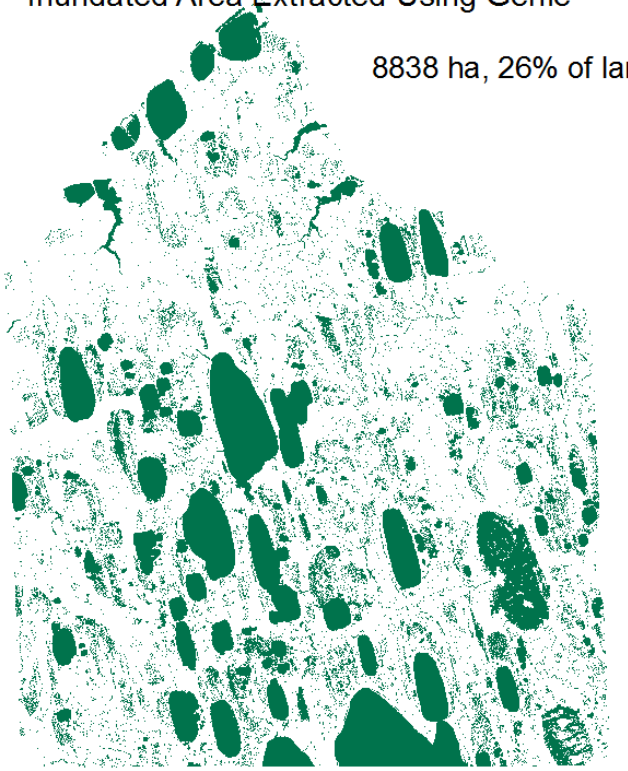


Use Genie to extract all inundated areas from WV2 data (Jul. 21, 2010) Chen et al. in prep



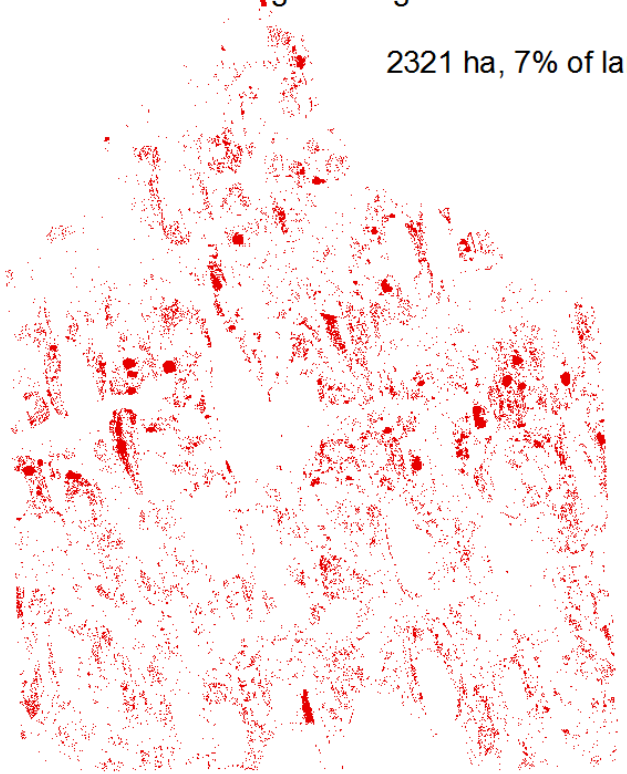
Inundated Area Extracted Using Genie

8838 ha, 26% of land area

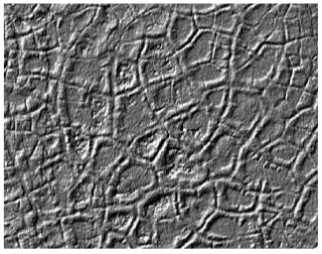


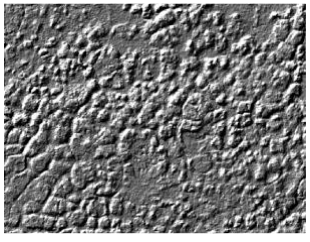
Inundated Area Exluding Existing Lakes and Rivers

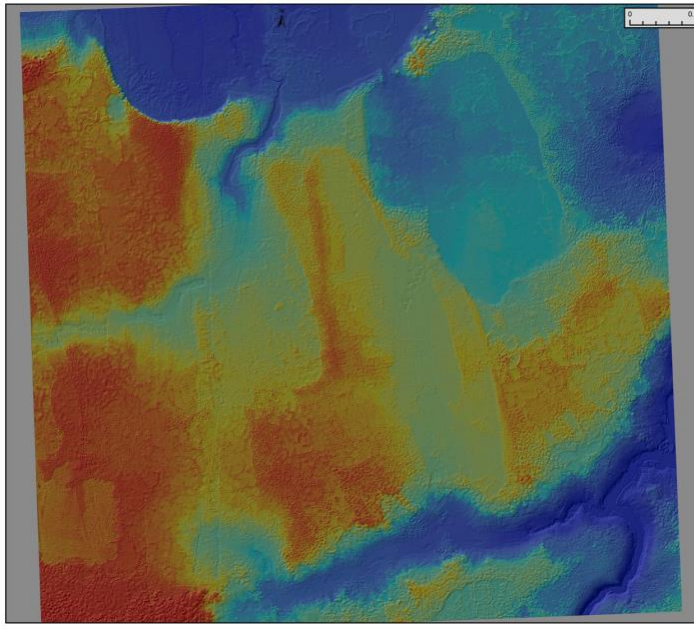
2321 ha, 7% of land area

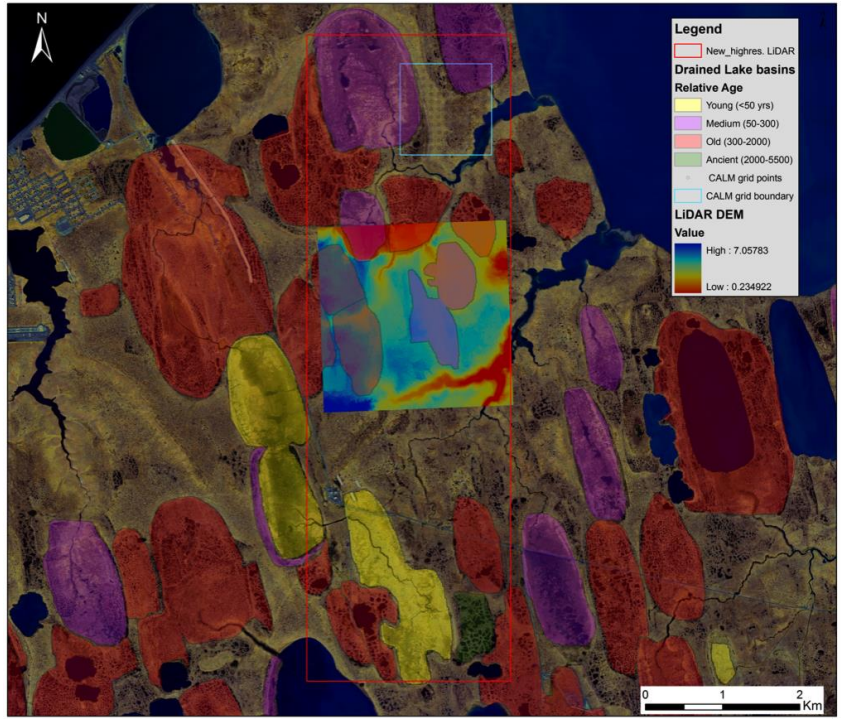


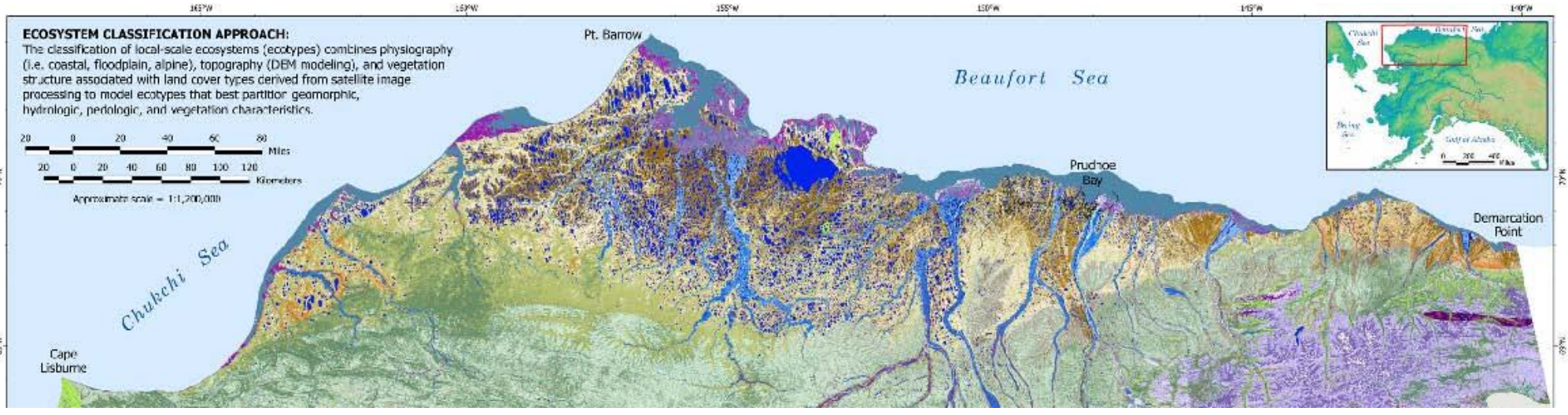
Perform a series of numerical experiments to test key hypotheses about climate warming impacts and feedbacks







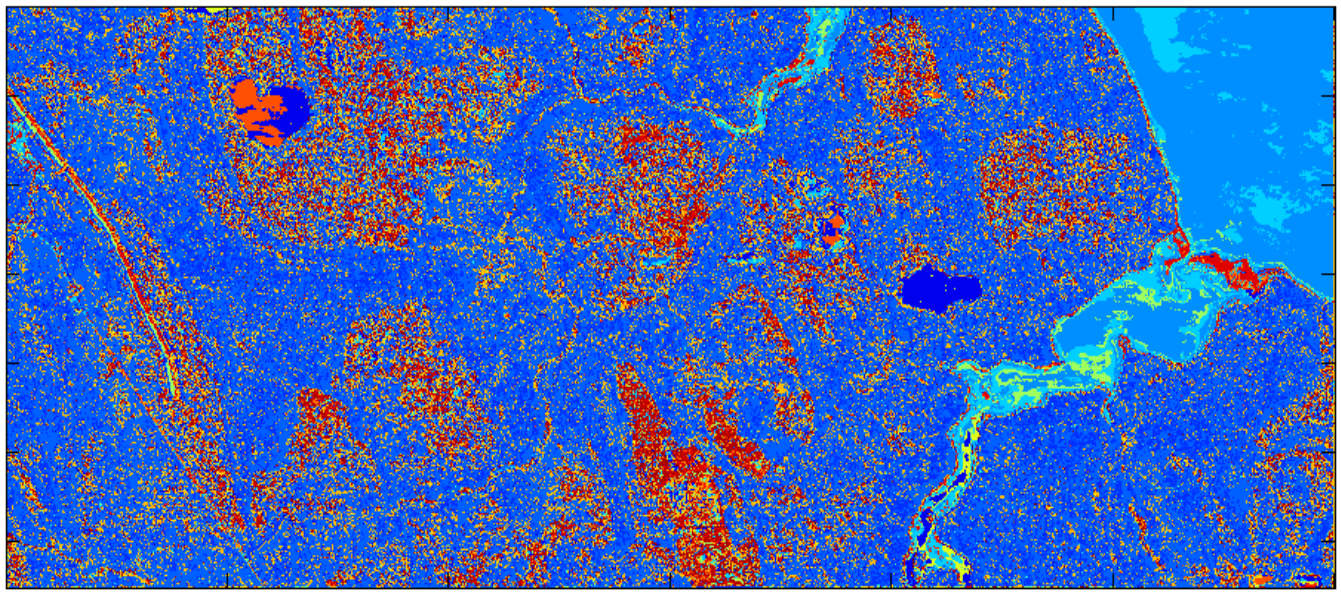




Land cover clusters (Barrow region)

Barrow area subimage (shown in Red/Green/Blue)

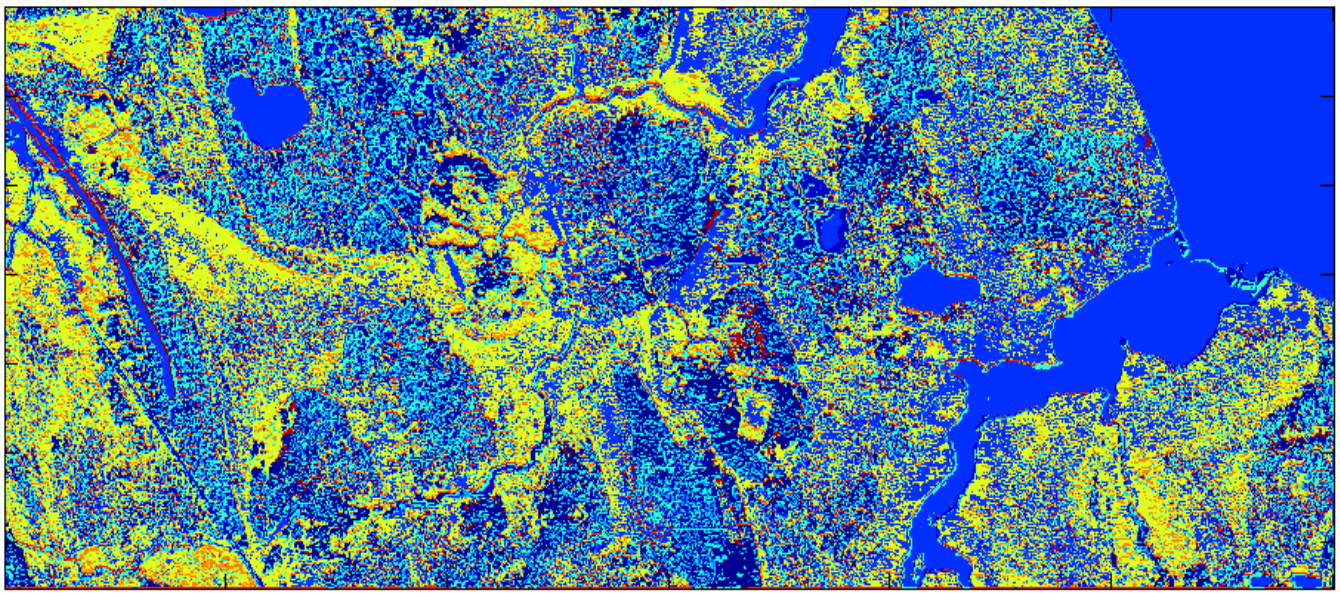
9x9 pixel patch
20 clusters



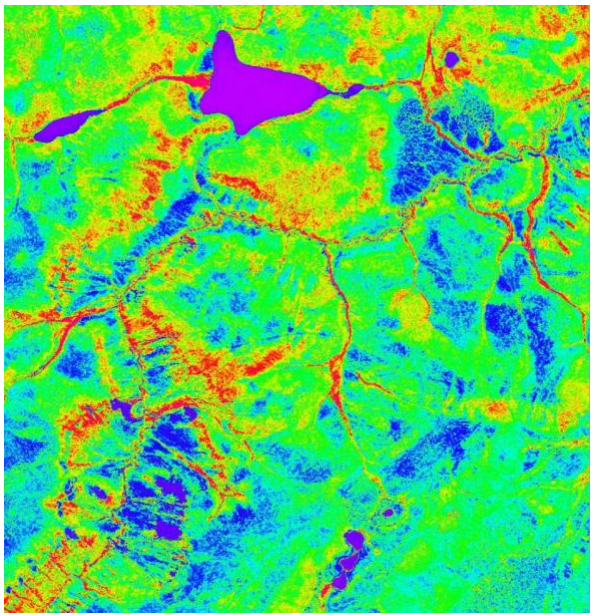
Land cover clusters (Barrow region)

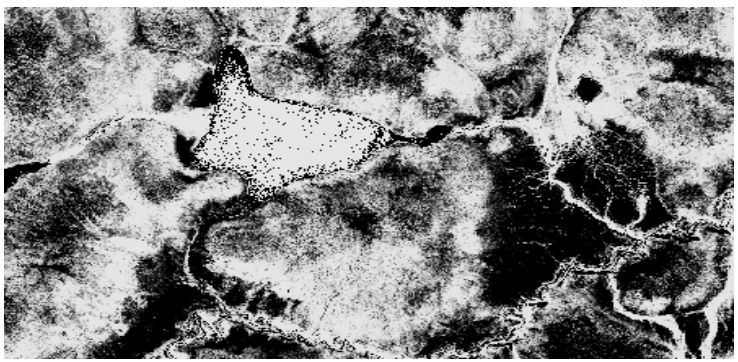
Barrow area subimage (shown in NIR2/RedEdge/Yellow)

7x7 pixel patch
20 clusters



Future work





- Exploit multiscale/multiresolution analysis tool
- Pre-condition the learning toward features of interest using band index
  - E.g., NDVI, NDWI, NDSI, NHFD
- Learn fusion dictionaries with Lidar data
- Develop quantitative performance metrics
- Explore land cover change detection in MSI