Laser Scanning of a Small Patterned Ground System

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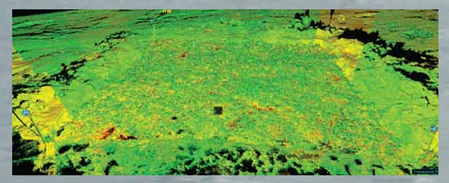
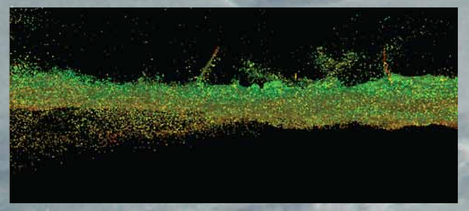




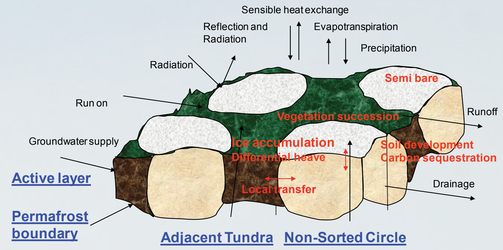
Non-sorted circles are a ubiquitous patterned ground formation in the arctic tundra. These features are not always visible at the surface due to vegetation cover. Research has shown that frost heave plays a major role in evolution of these features over time. The interaction of frost heave, hydrology and vegetation is a concept that is currently being researched. During freezing of the active layer water migrates from warm regions to cold regions, generated by snow and insulating vegetation. This migration leads to differential heave in the landscape. For this study we use a field site near Franklin Bluffs Alaska.

To measure differential heave we have applied a terrestrial laser scanner in spring and fall to understand frost heave and vegetation distribution in these systems. We use a Leica ScanStation 2 scanner and we processed the scan data with Cyclone. Due to vegetation and small topographical irregularities we scan the area from four different directions and integrate these scans into one point cloud using targets at each corner of our 10X10 meter research area. The large point cloud is than analyzed with our own software designed to sort the point cloud into layers and boxes.

In order to measure smooth frost heave pattern we subtract datasets after aligning them in space. Vegetation cover density was calculated using the vertical distribution of the point cloud. Relative cover density is calculated as the number of points above the ground surface (2cm) dived by the total number in that subplot.

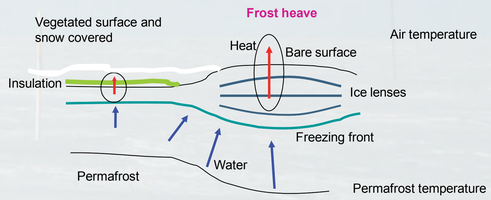
The data suggests that frost heave is greatest in regions with least vegetation cover surrounded by high vegetation cover and partially vegetated non-sorted circles show subdued frost heave. The overall heave in the non-sorted circles is between 10 and 15 centimeter using the inter-circle area as reference point with no frost heave.

Concept



Evolution Water, Ice and Temperature

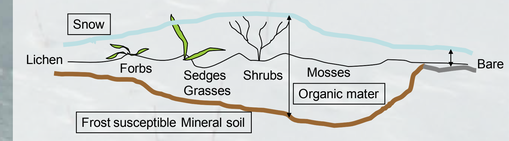
Heterogeneous Coupled Heat and Moisture transfer



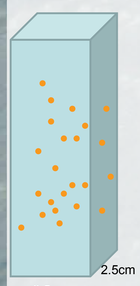
During freezing

Insulation estimation through vegetation characteristics

- The thermal differences are generated by snow, plant and soil properties
- N-factor (Kade, 2006)
  - Average condition of the insulation layer
- R-value
  - Specific condition related to depth and thermal conductivity of the layer

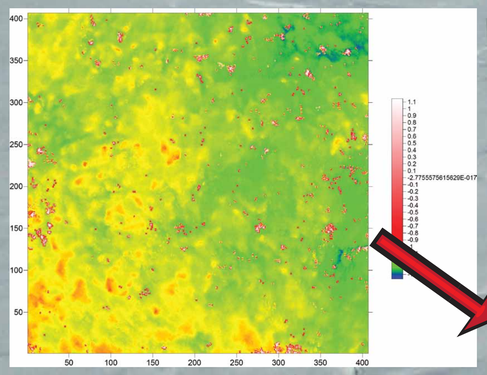


Data analyzes

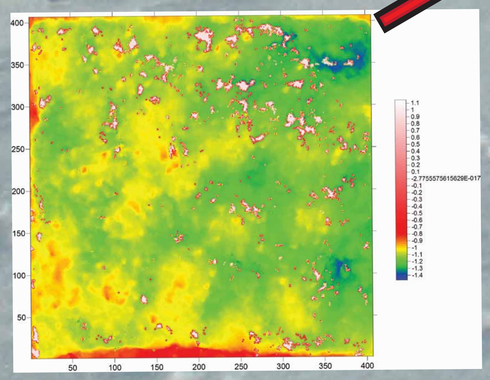


- Developed a Fortran code to sort the point cloud
- Divide 10X10m grid in 2.5cm squares (columns of points)
- Lowest point is the soil surface higher points are vegetation

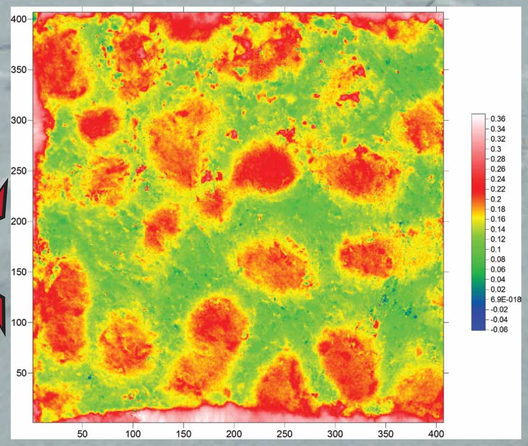
Fall elevation



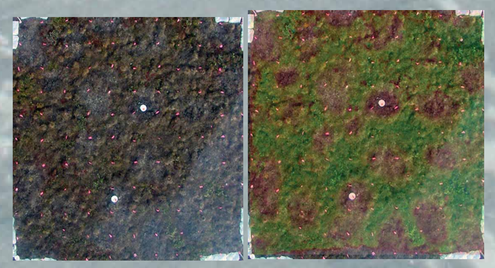
Spring elevation



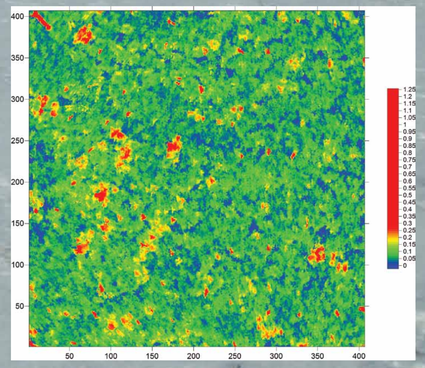
Frost heave



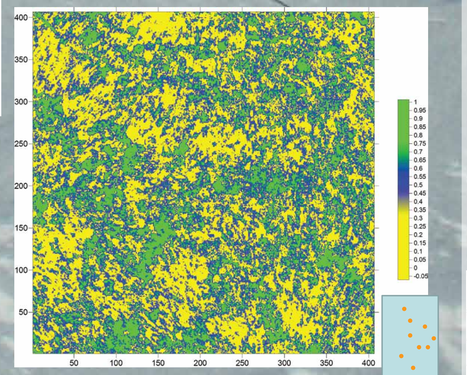
Aerial view and frost heave



Vegetation height



Vegetation canopy density



Relative number of points above the surface

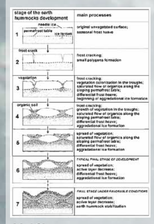
Colder tundra climate **Warmer tundra climate**

Modified from Chernov and Matveyeva 1997

Active layer depth

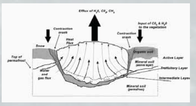
permafrost aggradation

Carbon sequestration



Yuri Shur

Non sorted circle



Earth hummock