Change Detection of Permafrost Thaw: Observations on Bykovsky, Lena Delta

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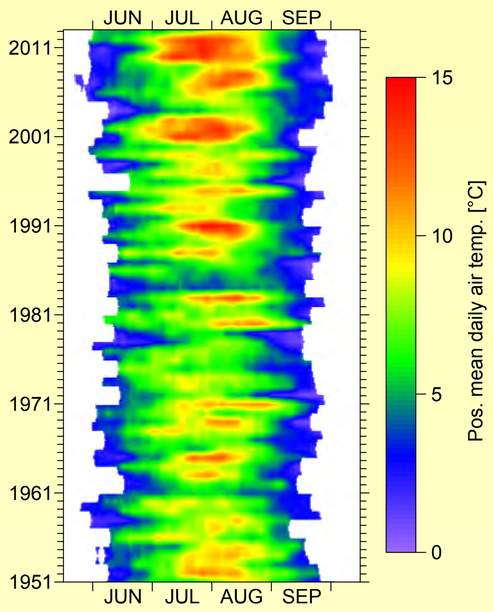
Background



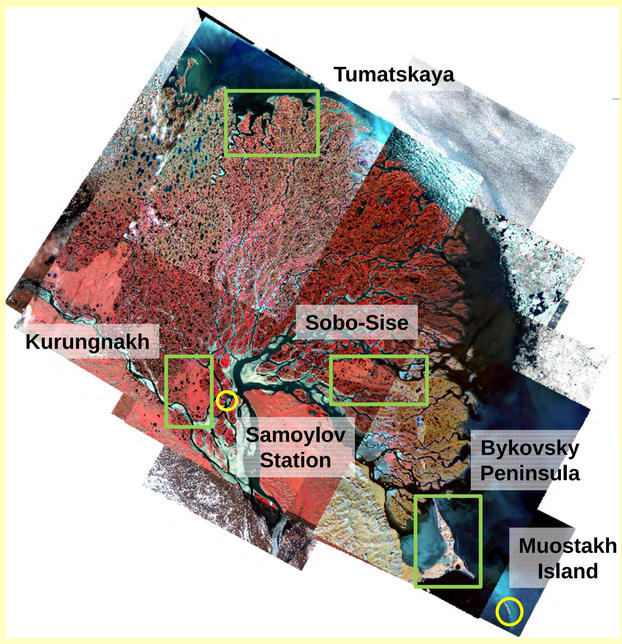
Time series of air temperature show lengthening and warming of the arctic summer in Tiksi. The season available for permafrost thaw has lengthened by two weeks. Simultaneously, T_{air} increased from 5.9 to 7.3 °C.

Objectives

How widespread is permafrost thaw, is it changing, and what are the implications for future landscape development in the Arctic?

- quantification and change detection of historical and modern thermokarst rates
- carbon mobilization through thaw-related terrain lowering (subsidence)
- hazard exposure to sea level rise

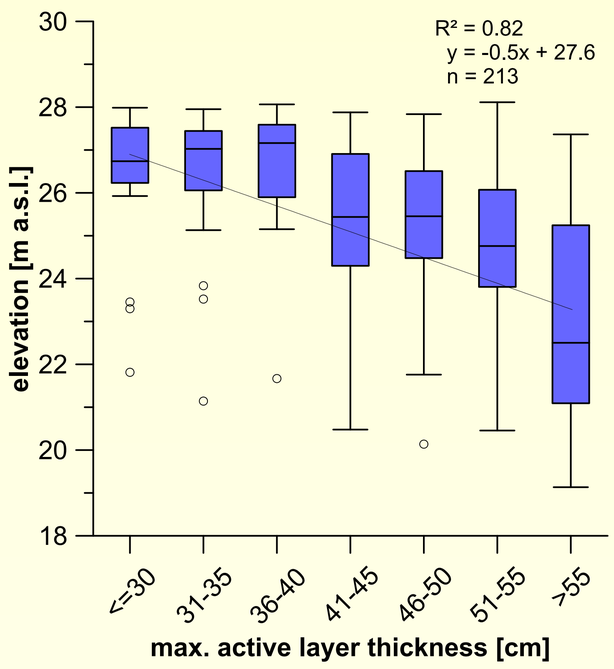
Study Region



Our focus in the Lena Delta region (East Siberia, Russia) is on areas with Yedoma prevalence, where we expect permafrost to be most sensitive to changing environmental conditions.

Field Work

During two subsequent expeditions in 2014 and 2015, topographic elevation data was collected by terrestrial laser scanning and tied to fixed reference markers. ALT 2015: 39 ±11 cm



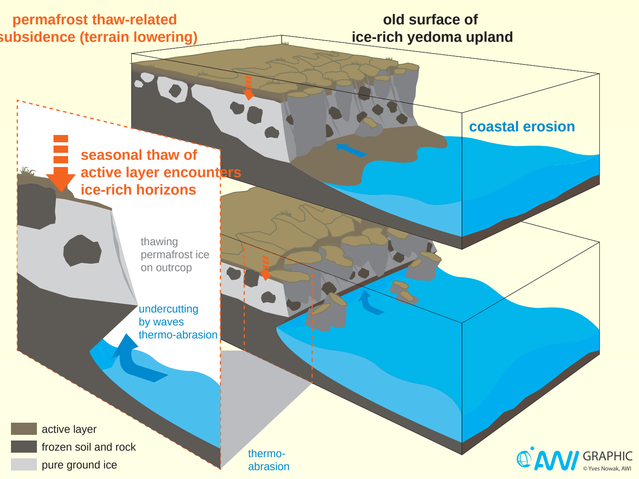
Measuring active layer thickness and mapping of a thin protective layer revealed high thaw vulnerability of yedoma uplands.

Data Fusion & Change Detection

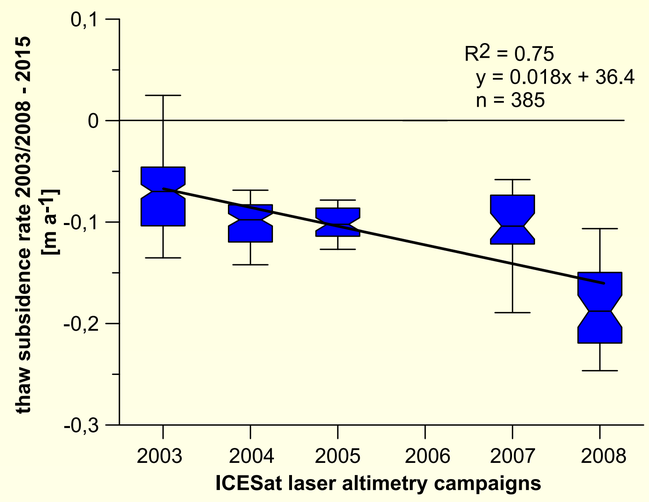
RapidEye scene draped over fusioned and quasi-simultaneous WorldView-1 and WorldView-2 DEM with previously unmatched detail at 0.5 m resolution. ICESat GLAS (Global Land Surface Altimetry) tracks build several profiles across the thermokarst-affected landscape.

- by creating robust photogrammetric image blocks of very high resolution multi-temporal satellite images (GeoEye, WorldView, QuickBird etc.), aerotriangulation, orthorectification, and thus data fusion is much more efficient and accurate
- simultaneous handling of all imagery through common tie points ensures best possible coregistration
- to span a long period of time for change detection, aerial imagery (1950s & 1980s) is used as basic datasets for 2D analyses
- Comparison of ICESat GLAS (release 34) data above ellipsoid with modern WV-DEM data captures elevation change during the warmest decade in the study region

Permafrost thaw-related terrain subsidence



Schematic diagram of terrain subsidence close to a retreating permafrost coastline. Local drainage gradients provide favorable conditions for removal of melt water from ground ice thaw.



Elevation differences between specific ICESat campaigns (early winter) and a WorldView DEM, representing the topography in August 2015. Elevation change over time suggests increasing terrain lowering in the recent past.

Conclusions and Outlook

Vast territories might be affected by thaw subsidence. Bykovsky will serve as super-observatory encompassing on-site monitoring for calibration of various remote sensing approaches measuring elevation change. Based on operational topography products such as from stereo VHR imagery and TanDEM-X, we will expand this study to larger, arctic-wide scales.