Rapid Permafrost Thaw Dynamics

Remote Sensing and Modeling of Landscape Dynamics

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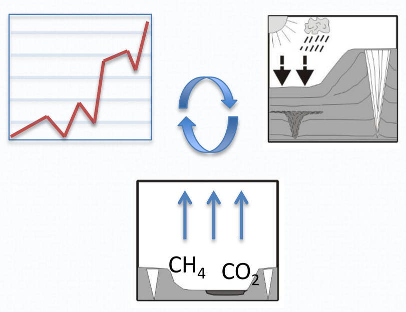
Introduction

3 yr PhD project (2014-2017)
ERC-funded PETA-CARB project –
Rapid **Pe**rmafrost **T**haw in a Warming **A**rctic and Impacts on the Soil Organic **Carb**on Pool

Project Objective
Spatio-temporal dynamics of rapid permafrost thaw processes



Methods
Remote sensing time-series,
Data analysis/pattern recognition,
Field work

Goals
a) Detection of thermokarst lake shore dynamics
b) Automated monitoring of thaw processes
c) Development of landscape process models

Key Study Sites

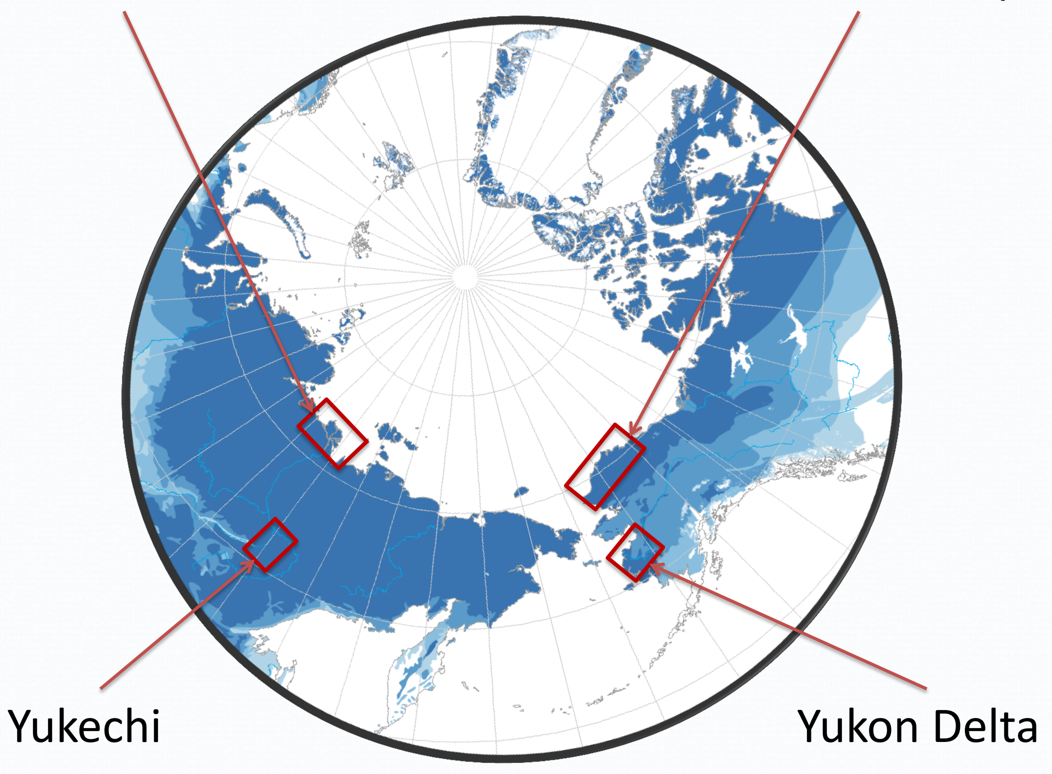


Fig 1: Key Study Sites. Map altered after Brown et al. (1997).

Study Areas
Permafrost regions across Siberia and Alaska with different conditions:

- Climate
- Landscape
- Data Availability

Data and Time-Series

Remote Sensing Time-Series
Main Data Sources:
Landsat, RapidEye

- High acquisition frequency – daily to bi-monthly
- Large spatial coverage
- Good spectral range
- Mission security

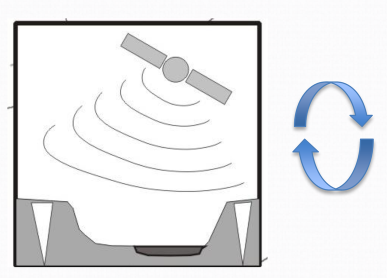
Additional Data Sources:
DEM, aerial imagery (historic, recent), VHR optical data, field measurements

Time-Series Analysis
Rapid detection of sudden changes (e.g. lake drainage)
Monitoring of gradual changes (subsidence, lake formation)
Application of state-of-the art time-series processing methods – e.g. TIMESAT, BFAST

Methods and Analysis

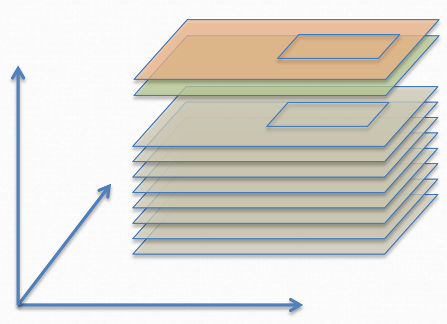
Continuous Data Acquisition

- Automatic acquisiton tracking and retrieval
- Minimize cloud contamination due to high frequency



Automated Data Processing Environment

- Data download
- File operations
- Image stacking/redistribution
- Atmospheric correction
- Index calculation
- Subsetting



Temporal Analysis

- Seasonal to decadal scale (data availability)
- Analysis of different multi-spectral indices
- Extract temporal signatures

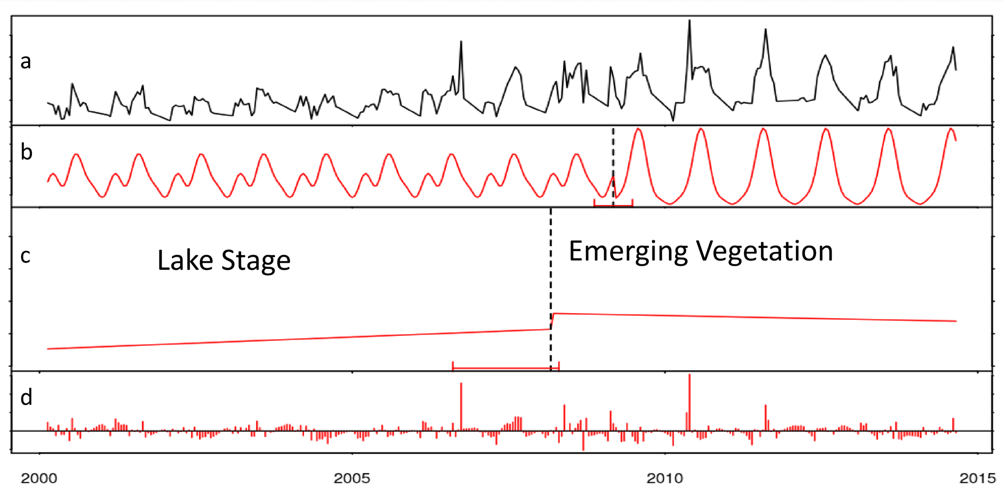


Fig. 2: Bfast-Analysis Plot: MODIS EVI Time-Series of Drained thermokarst lake, acquired from webEOM (http://www.earth-observation-monitor.net). a: Raw signal, b: Seasonal signal, c: Signal trend, d: Noise fraction.

Spatial Analysis

- Spatial patterns and interconnections
- Anthropogenic impact
- Detection of process scale

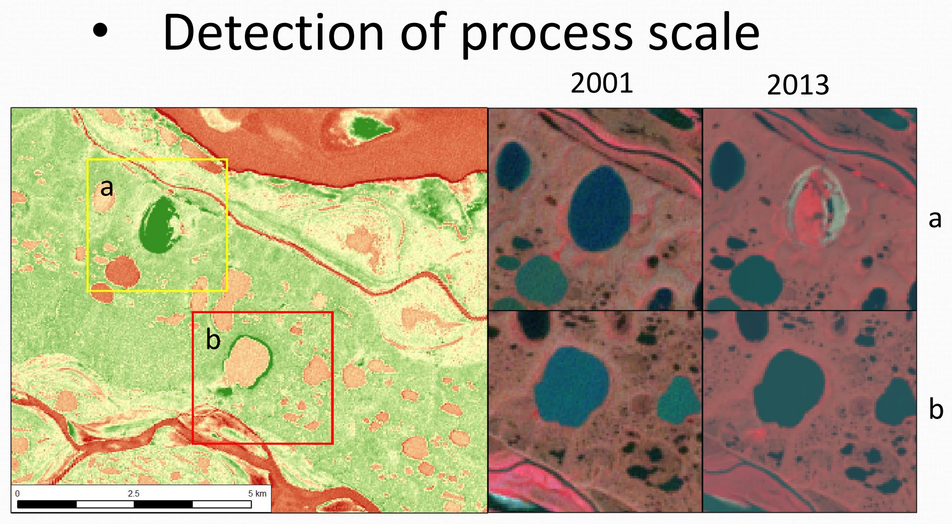


Fig. 3: Greening trend between 2001 and 2013 based on Landsat Greenness Tasseled Cap index. a: Drained lake with emerging vegetation (see also Fig.2). b: Dropped lake level, due to altered drainage regime. Lake shore erosion in eastern lake. Landsat 5 TM (2001) and Landsat 8 OLI (2013) in Color-Infrared (NIR-R-G).

Outlook

Field work for calibration, validation and data collection
Lena Delta 2014, Alaska 2015

Field Work

Spatio-Temporal Process Model

Analyze

Optimize

Comparison of study areas

Landscape dynamics

Data Analysis

Continuous output/update for calculation of thermokarst related carbon fluxes

Geoscience

Provide toolkit/software library for large scale analysis
Integration with other remote sensing time-series models/analysis tools (e.g. LandTrendr, webEOM, TIMESAT)

Technology

Multiple disciplines will benefit from a better knowledge of the spatio-temporal thermokarst landscape dynamics

References
Brown, J., Ferrians, Jr. O. J., Heginbottom, J. A., and Melnikov, E. S.: Circum-Arctic map of permafrost and ground-ice conditions, 1:10 000 000, Map CP-45, United States Geological Survey, International Permafrost Association, 1997.

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