Thermokarst lake dynamics across the Arctic based on Landsat time-series

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Introduction

Observed and projected climate change in the Arctic increases the vulnerability of terrestrial ecosystems to disturbances. For example, significant increases in air temperatures especially in high latitudes (Polar amplification) will impact the stability of permafrost landscapes that cover 24% of the northern hemisphere and dominate large parts of the Arctic. So far, only small areas have been monitored regarding their landscape dynamics related to permafrost in an appropriate spatial scale. This study seeks to overcome this massive knowledge gap with an integrated geo-informatics approach based on remote sensing time-series.

Challenges

- Rapid landscape dynamics
- Remote locations
- Large spatial extent
- Cloud and snow cover
- Data processing and handling

Current Knowledge Base

- Only knowledge of local dynamics
- Pan-Arctic lake data too coarse and static
- Large diversity of data and methods
- Little knowledge about the Big Picture

Goals

- Monitoring of TKL dynamics
- Scalable and transferrable process
- Transferability and integration with other sensors (Sentinel-2)
- Product easy to use and understand by stakeholders

Methods - Data Processing

Automated Data Processing

Usage of the full Landsat archive (TM, ETM+, OLI)
- Peak summer season (Jul, Aug), CC < 90 %
- Years 1984/1999 to 2014
- 1000’s of scenes around the Arctic

Data pre-processing (Subset, Reproject, FMask, Stack)

Index calculation: Tasseled Cap, NDVI, NDMI, NDWI

Trend Calculation

- Linear trend/regression of index values over time
- Robust Theil-Sen-regression
- Output: Slope, Intercept, Confidence Intervals

For detailed info see: Nitze & Grosse (2016)

Methods - Trend Analysis

Temporal Landscape Dynamics

Fig 1: Overview of Study sites. A: Lena Delta and Yakutia, B: Kolyma, and C: Seward Peninsula and North Slope. D: Overview of Study sites within the Arctic permafrost region. Modified after Brown et al. (1997).

Methods - Lake Analysis

Classification

Methods - Object Recognition

Quantification

Summary and Outlook

Land surface trend analysis on Landsat archive

Automated lake detection and characterization

Transferable approach across the Arctic

Varying thermokarst lake dynamics between regions

Integration of higher resolution Sentinel-2 data

Development of dynamic pan-Arctic thermokarst lake database

Distribution of result datasets via Open Access data portal (Arctic Permafrost Geospatial Centre & PANGAEA)

This research was supported by ERC Starting Grant #338335 and the Initiative and Networking Fund of the Helmholtz Association (NERC-0013).