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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 and ice cover
Data processing and handling

Current Knowledge Base
Only knowledge of local dynamics
Global Surface Water problematic in high latitudes
Large diversity of data and methods
Little knowledge about the **Big Picture**

Goals
Monitoring of thermokarst lake dynamics
Upscaling capabilities
Product easy to use and unterstand by stakeholders
Improved unterstanding of processes

Methods - Data Processing

Usage of the full Landsat archive (TM, ETM+, OLI)
- Peak summer season (Jul, Aug), Cloud Cover < 70 %
- Years 1999 to 2014
- 1000‘s of scenes around the Arctic

Data pre-processing (Subset, Reproject, FMask, Stack)
More Info: Nitze & Grosse (2016)

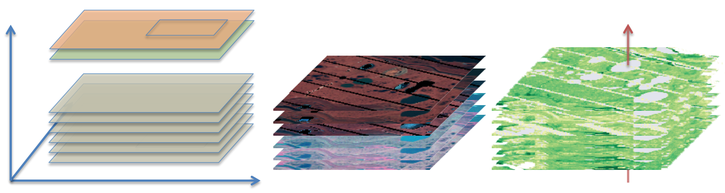


Fig 1: Drained lake margin on the Alaska North Slope. Photo: I.Nitze

Fig 2: Eroding thermokarst lake shore on the Alaska North Slope. Photo: I.Nitze

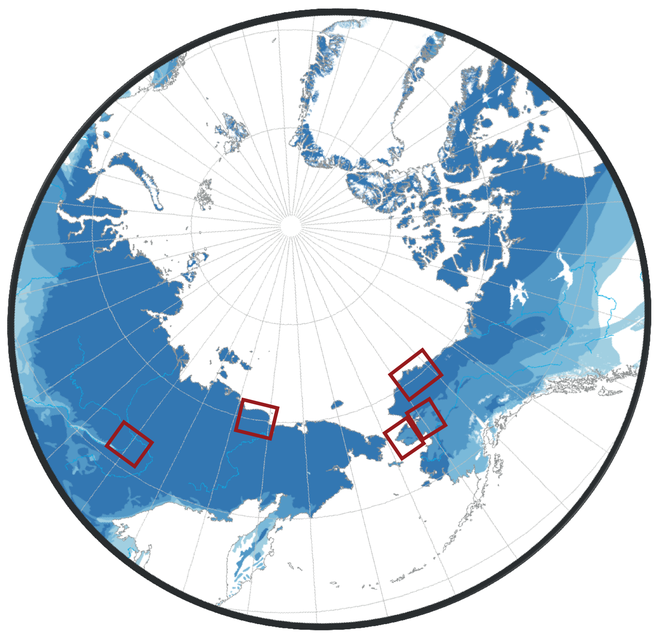


Fig 3: Permafrost region with overview of study sites: Central Yakutia, Kolyma Region, Seward Peninsula, Kobuk-Selawik Region, Alaska North Slope

Lake change analysis (> 1ha)
Several sites across Arctic
15yr Observation Period
Automated Processing

Methods - Lake Change Analysis

Machine-learning classification of processes
Object based data analysis
Statistical analysis

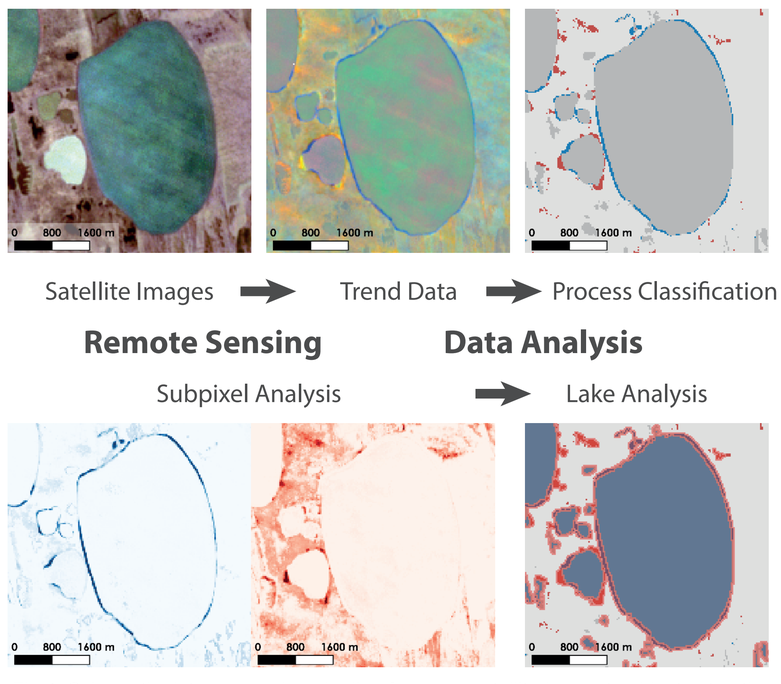
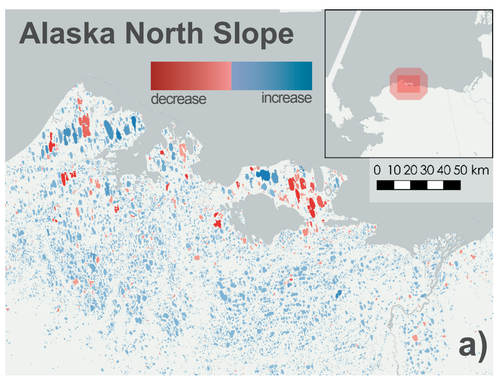
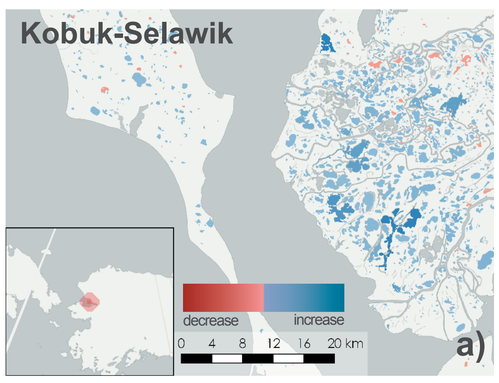


Fig 4: Schematic data processing pipeline from raw satellite Image to object extraction and lake change calculation.

Results - Regional Statistics





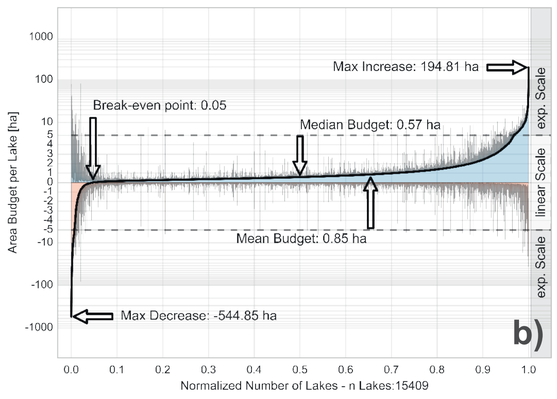


Fig 5: a) Map of lake specific surface water area changes on the Alaska North Slope. b) Statistical Lake area change distribution on the Alaska North Slope.

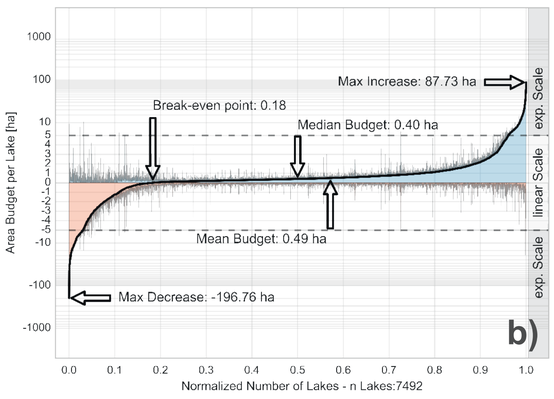


Fig 6: a) Map of lake specific surface water area changes in the Kobuk-Selawik Delta Region. b) Statistical Lake area change distribution in the Kobuk Delta.

Lake growth dominates
95 % of all lakes are growing
high frequency of low growth
few partial drainage events

Regional differences
strong dynamics along coast

Lake growth dominates
82 % of all lakes are growing
frequent full drainage events

Regional differences
strong general dynamics (+ and -)
flooding in river delta

Results - Regional Comparison

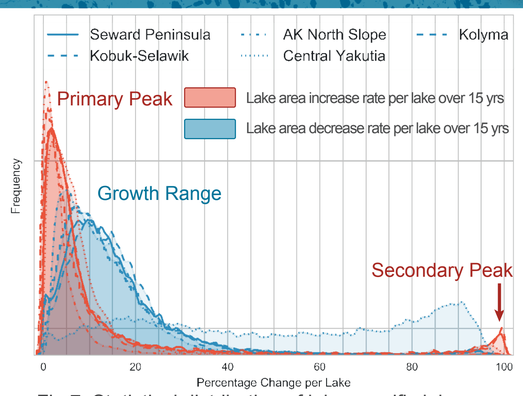


Fig 7: Statistical distribution of lake specific lake area increase and decrease rates.

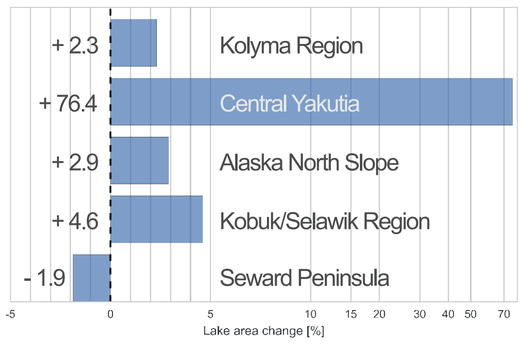


Fig 8: Regional lake area change budget.

Thermokarst lake drainage
high frequency of low values
occasional full drainage events

Thermokarst lake growth
typical range up to 40 %
lake size dependent

Regional lake area budgets
predominantly lake area growth
typical range up to + 5 %
extreme change in Central Yakutia
slight decrease on Seward Pen.

Conclusions

Highly scalable automated lake analysis
Lake area budget is a highly regional signal
Lake expansion (thermokarst) dominating process
Drainage events important for regional budget
Allows enhanced assessment of underlying hydrological dynamics

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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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