

Landsat-Based Trend Analysis of Lake Dynamics across Northern Permafrost Regions

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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
Large quantity of lakes
Remote locations, large extent
Data processing and quality

Current Knowledge Base

Knowledge of local dynamics
Large diversity of data and methods
Little knowledge about the **Big Picture**
Limited quality of existing products

Goals

Monitoring of thermokarst lake dynamics
Upscaling capabilities
Product easy to use and understand by stakeholders
Improved understanding 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)

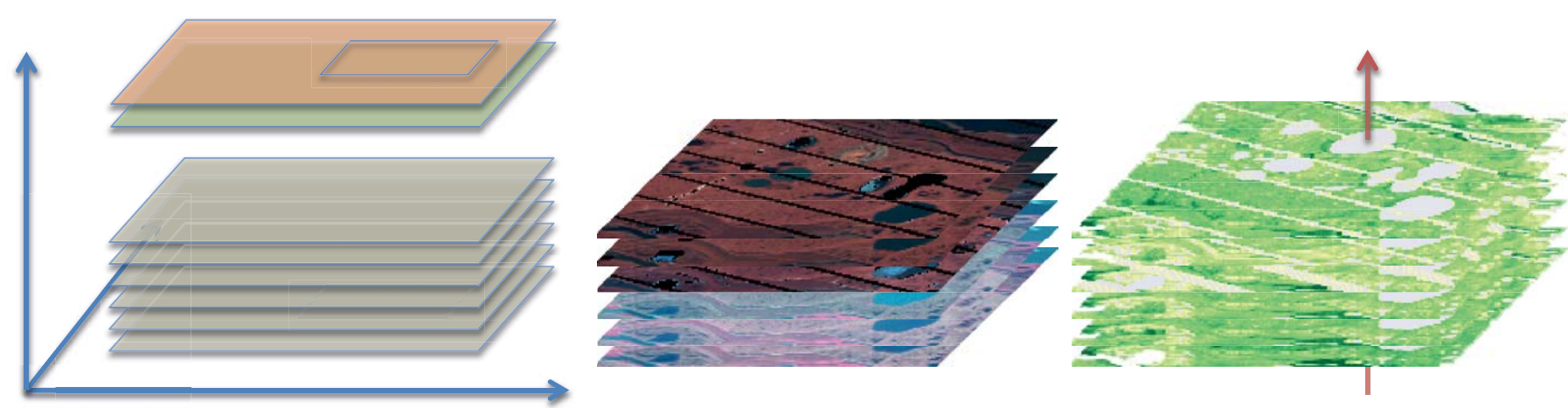


Fig 1: Drained lake margin on the Alaska North Slope. Photo: I. Nitze



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

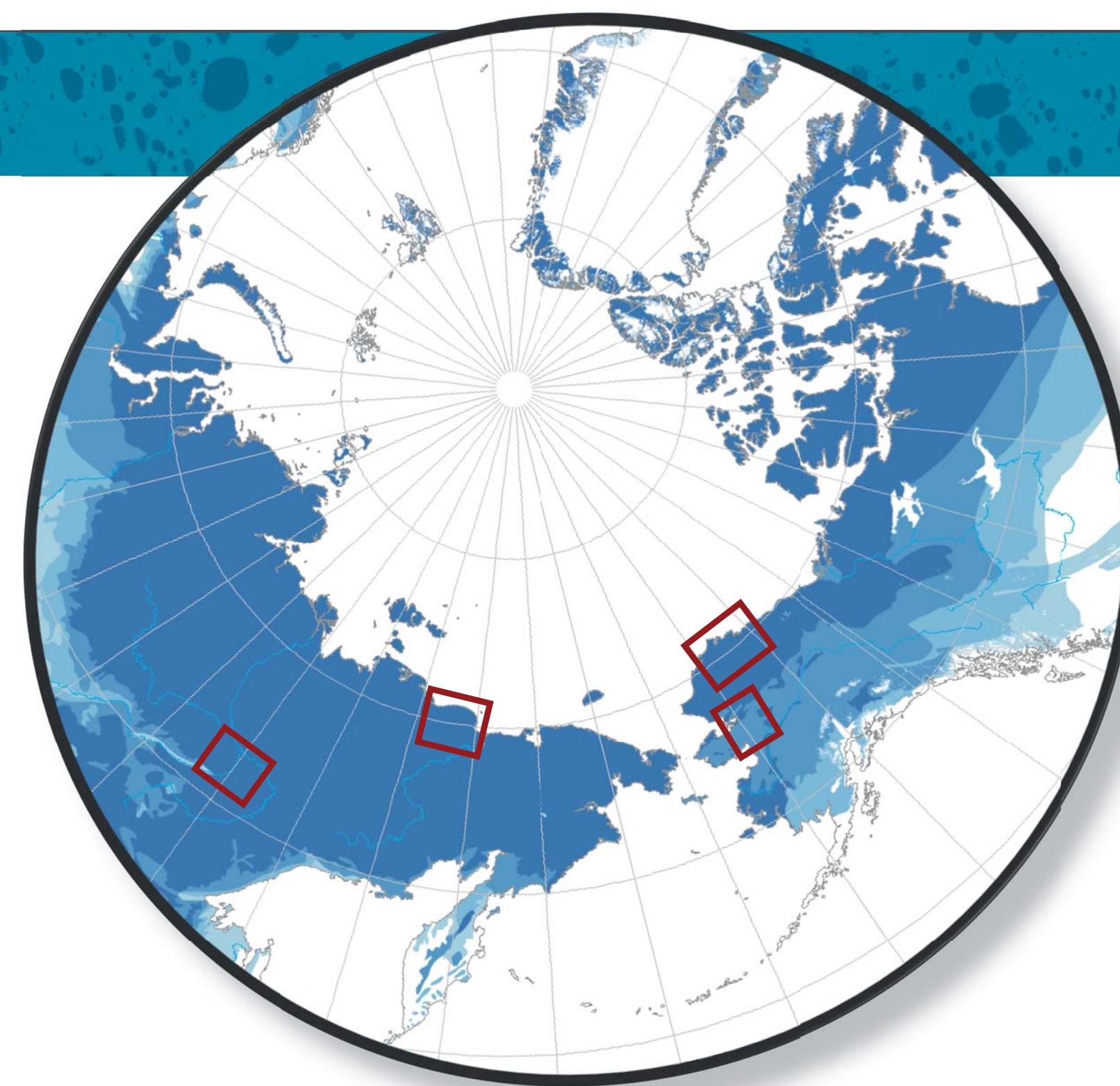


Fig 3: Permafrost region with overview of study sites: Central Yakutia, Kolyma Lowland, Kobuk-Selawik Lowlands, and Alaska North Slope

Lake change analysis (> 1ha)
Several sites across (Sub-)Arctic
16yr Observation Period: 1999-2014
Automated Processing

Methods - Lake Change Analysis

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

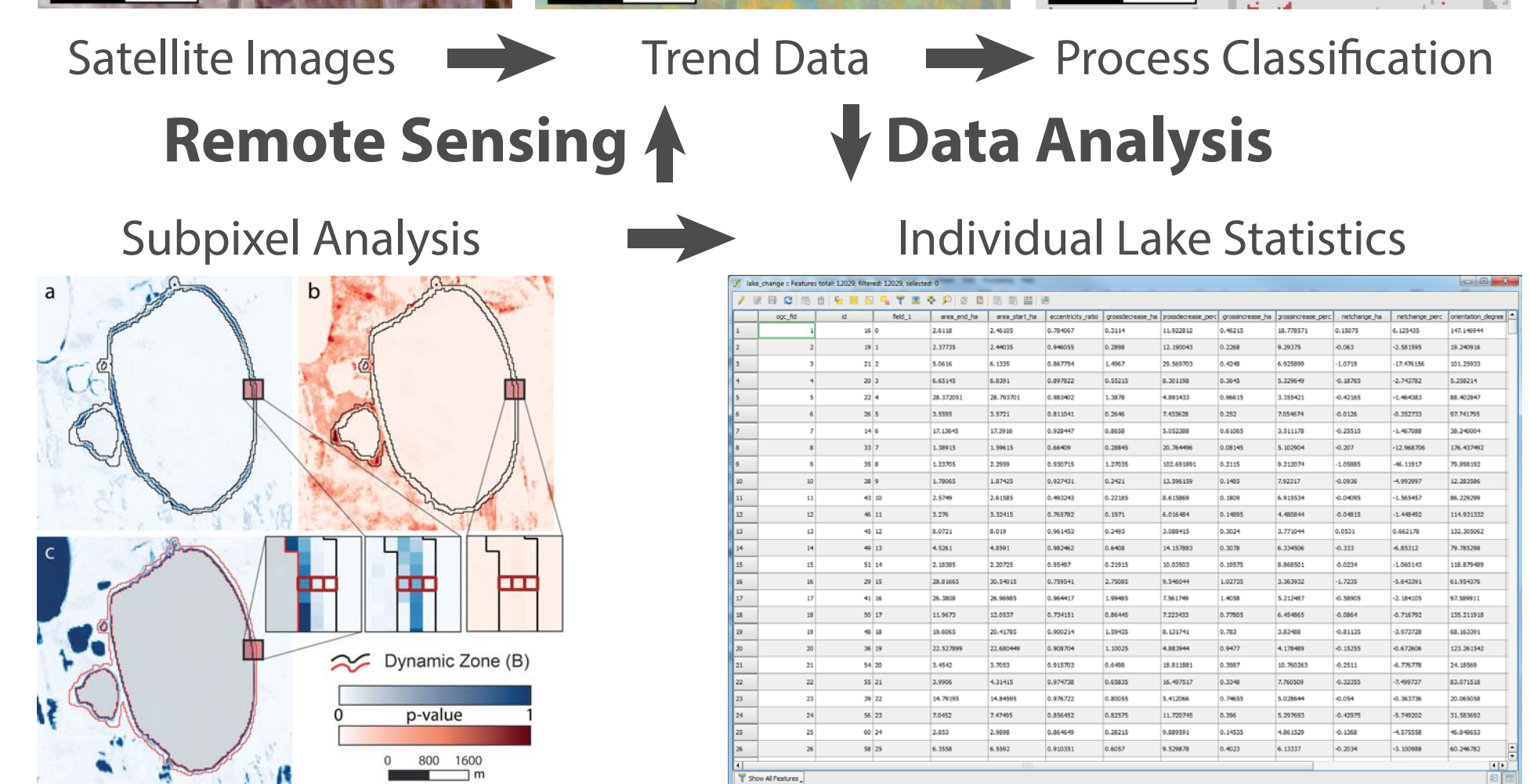
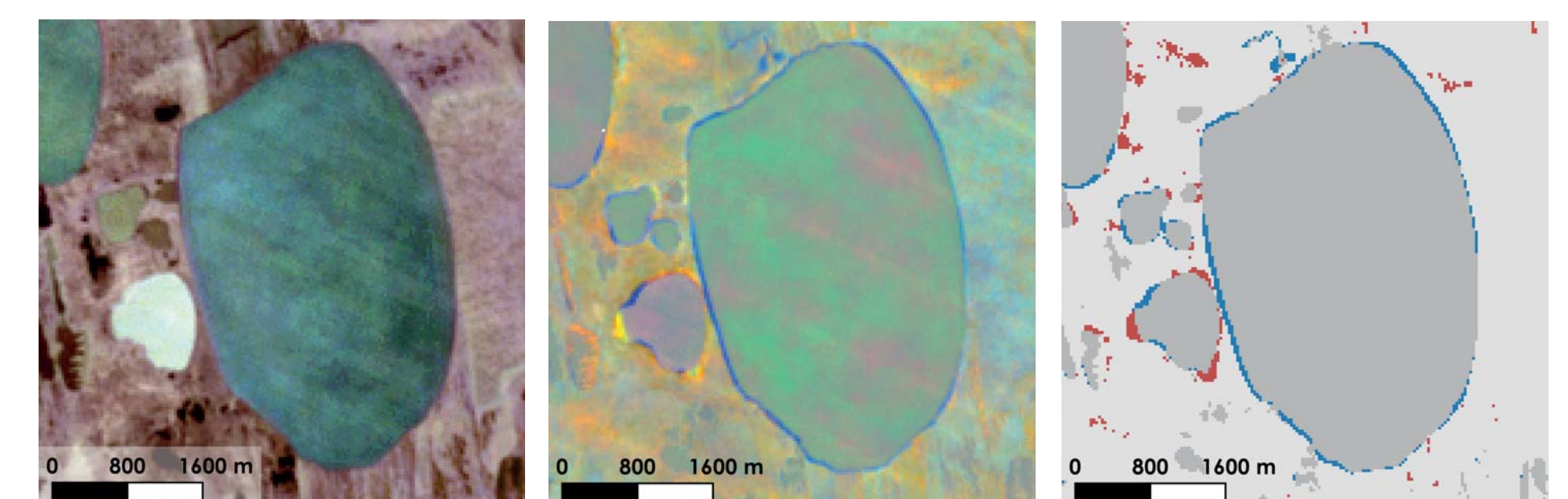
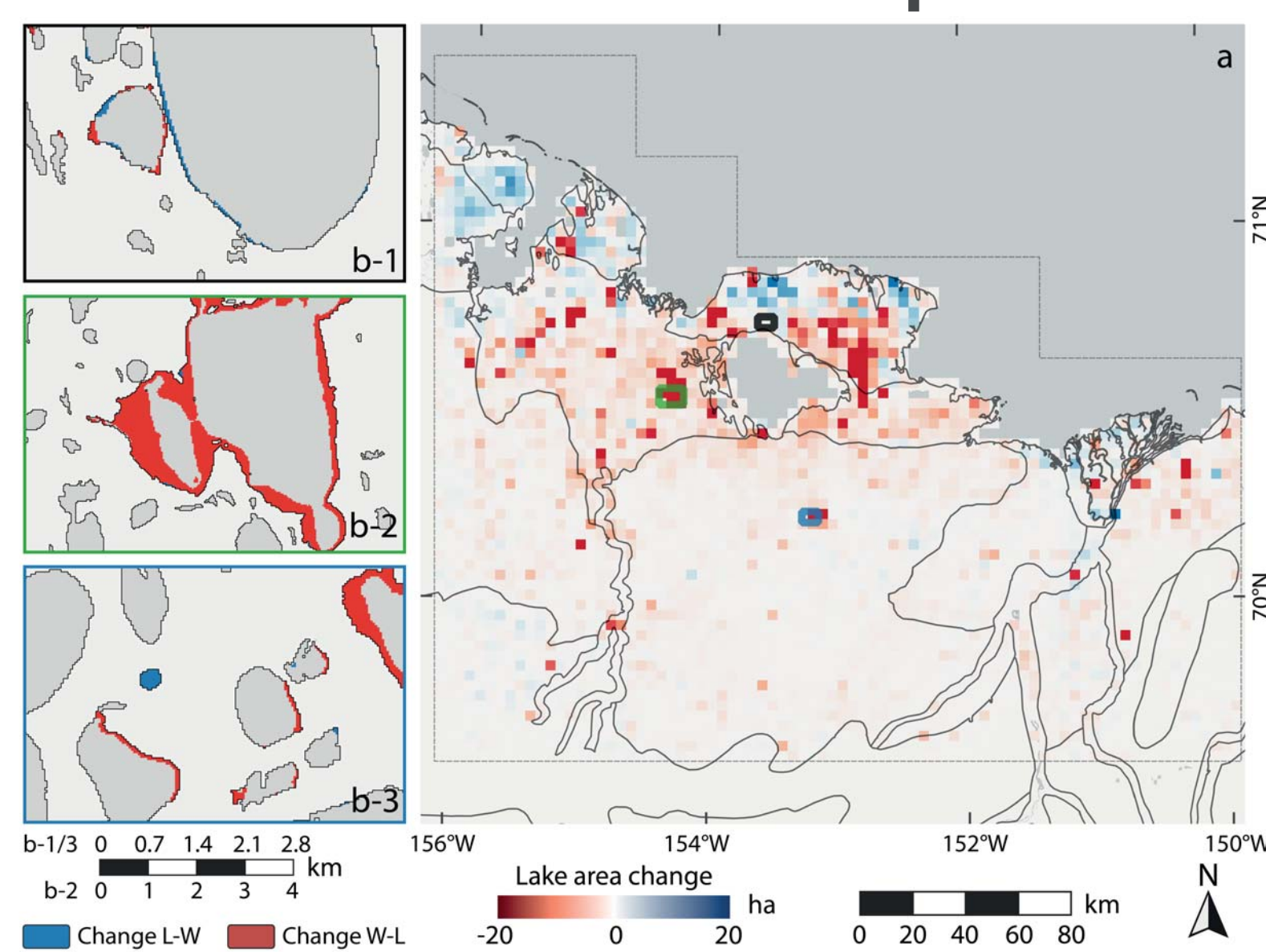


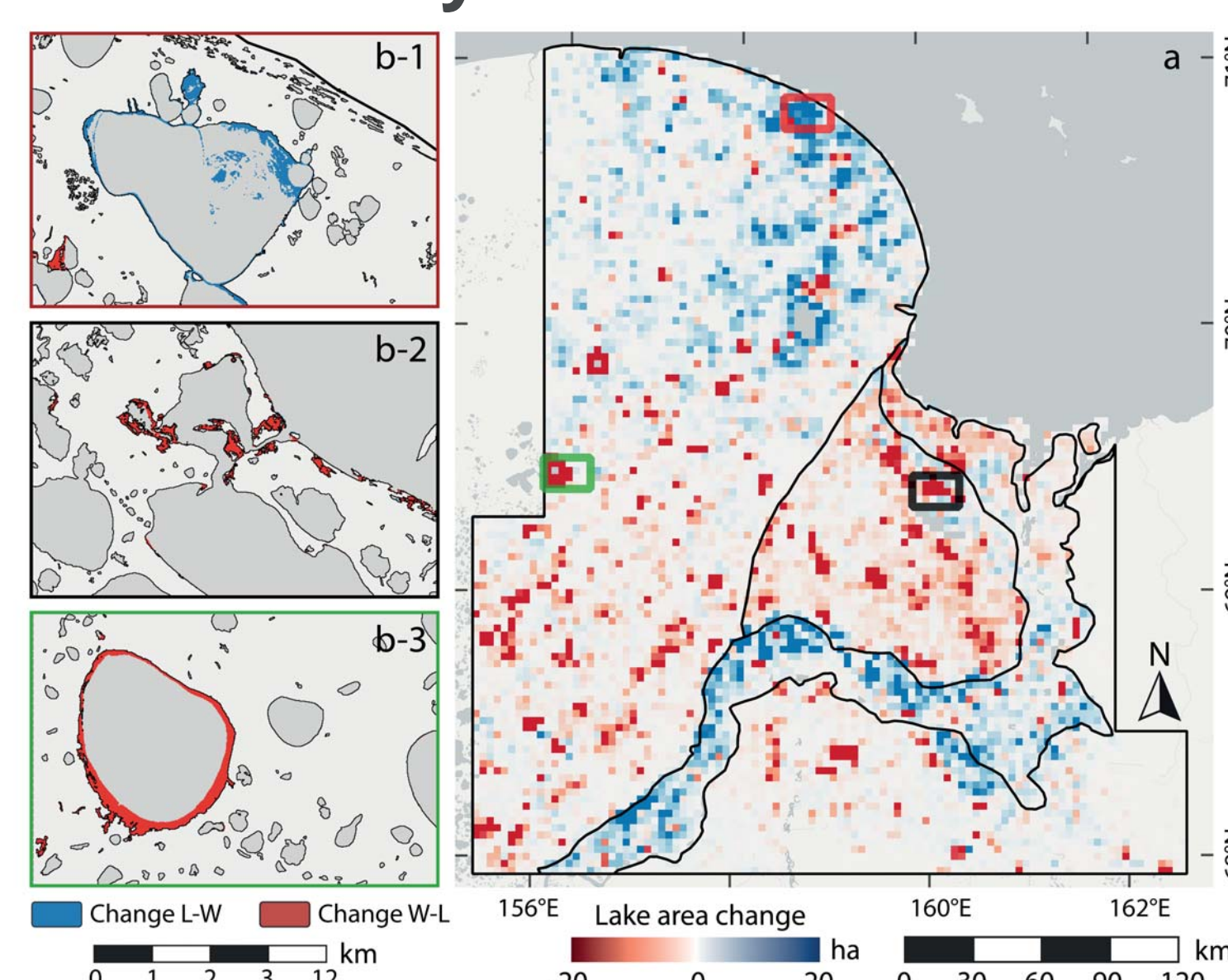
Fig 4: Schematic data processing pipeline from raw satellite Image to object extraction and lake change calculation.

Results - Regional Statistics

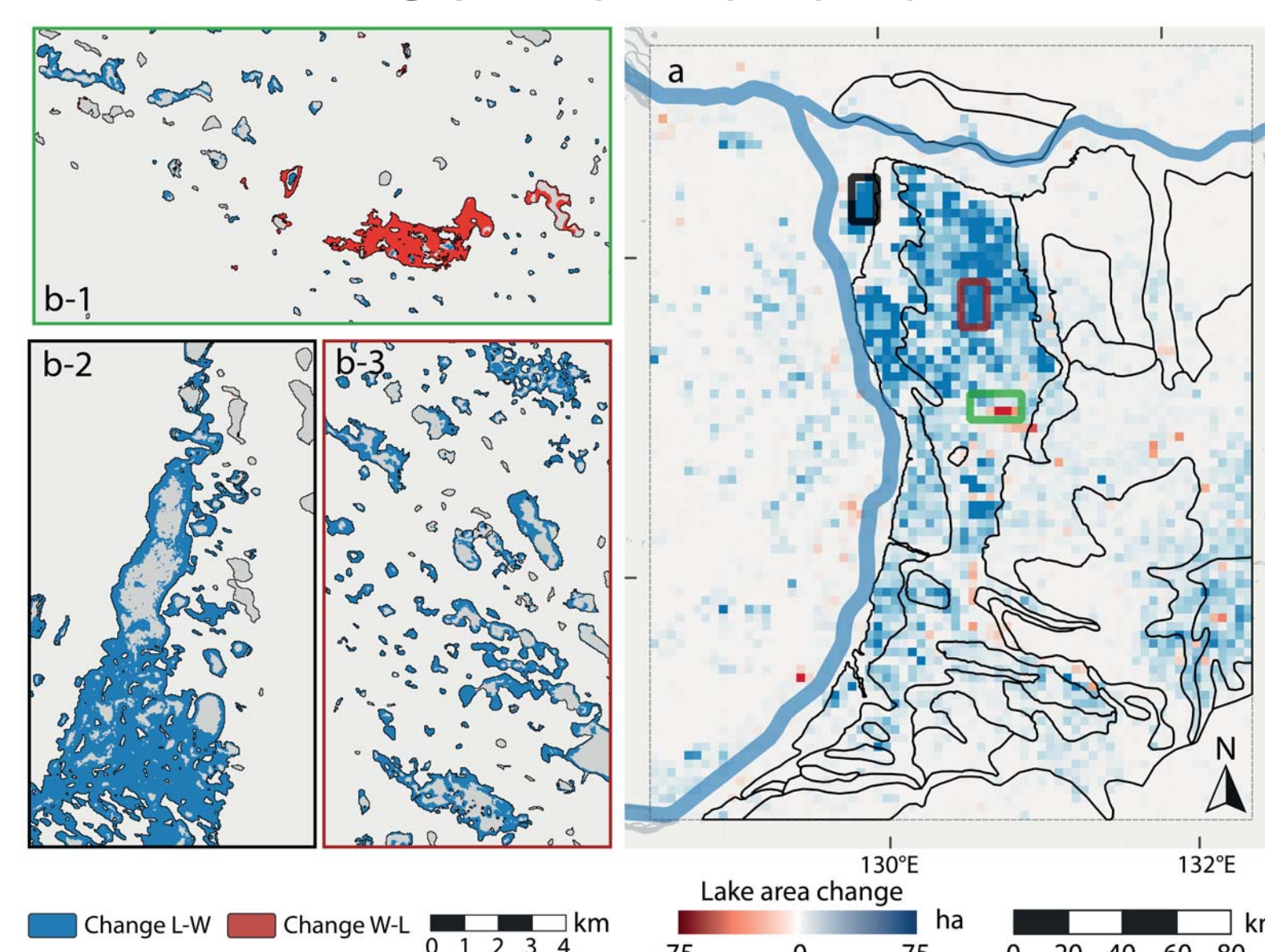
Alaska North Slope



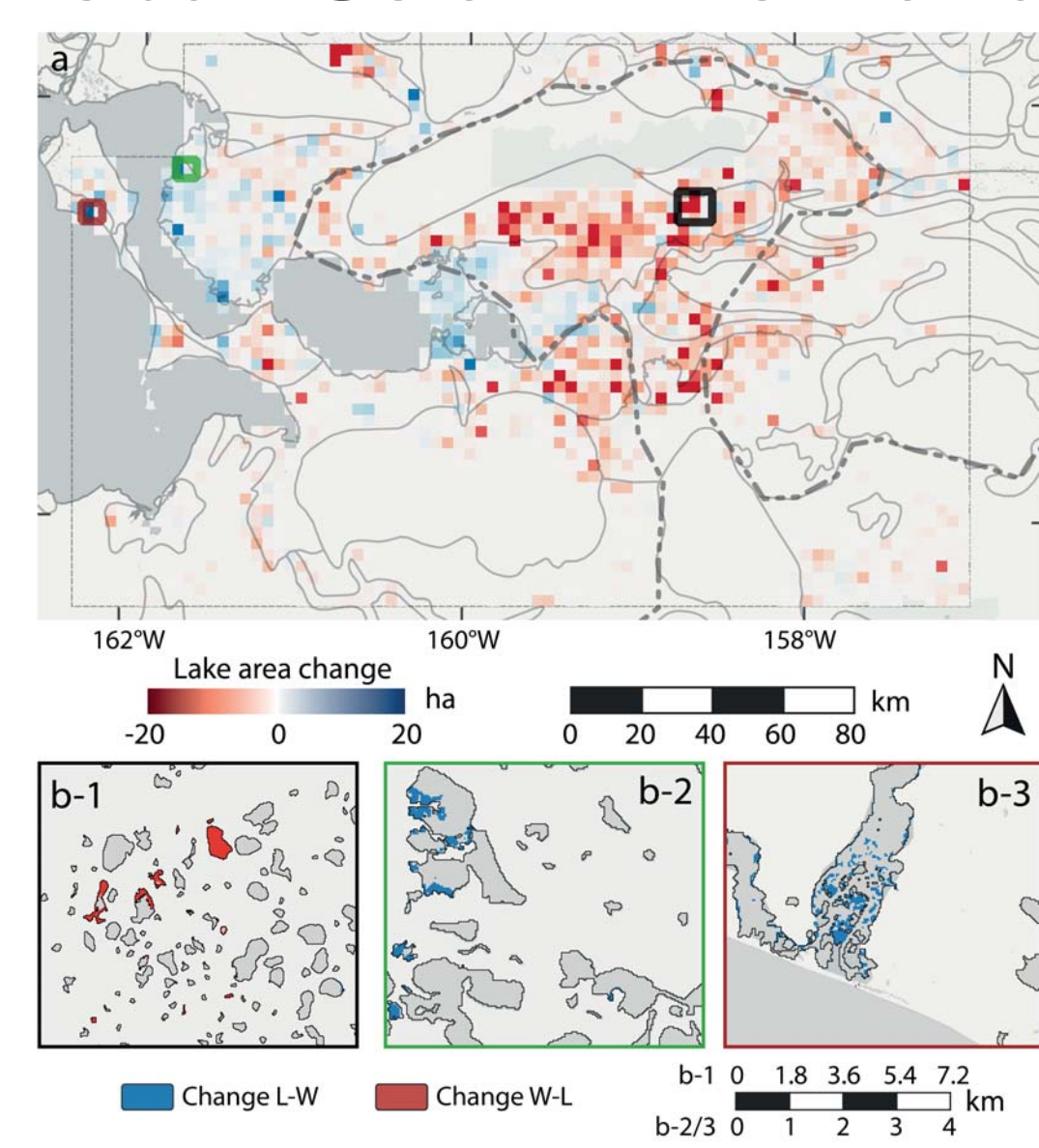
Kolyma Lowland



Central Yakutia



Kobuk-Selawik Lowlands



Figs. 5-8: Spatial distribution of net lake change in the four study sites in Alaska and Siberia. Lake changes gridded into 3x3 km large cells.

Results - Regional Comparison

Continental Scale

- Diverse lake change across permafrost region
- Massive lake area gain in Central Yakutia
- Slight lake loss in High Arctic sites
- Frequent lake drainage in western Alaska

Regional Scale

- Local diversity and zonation
- Geology/Geomorphology
- Ground-ice conditions

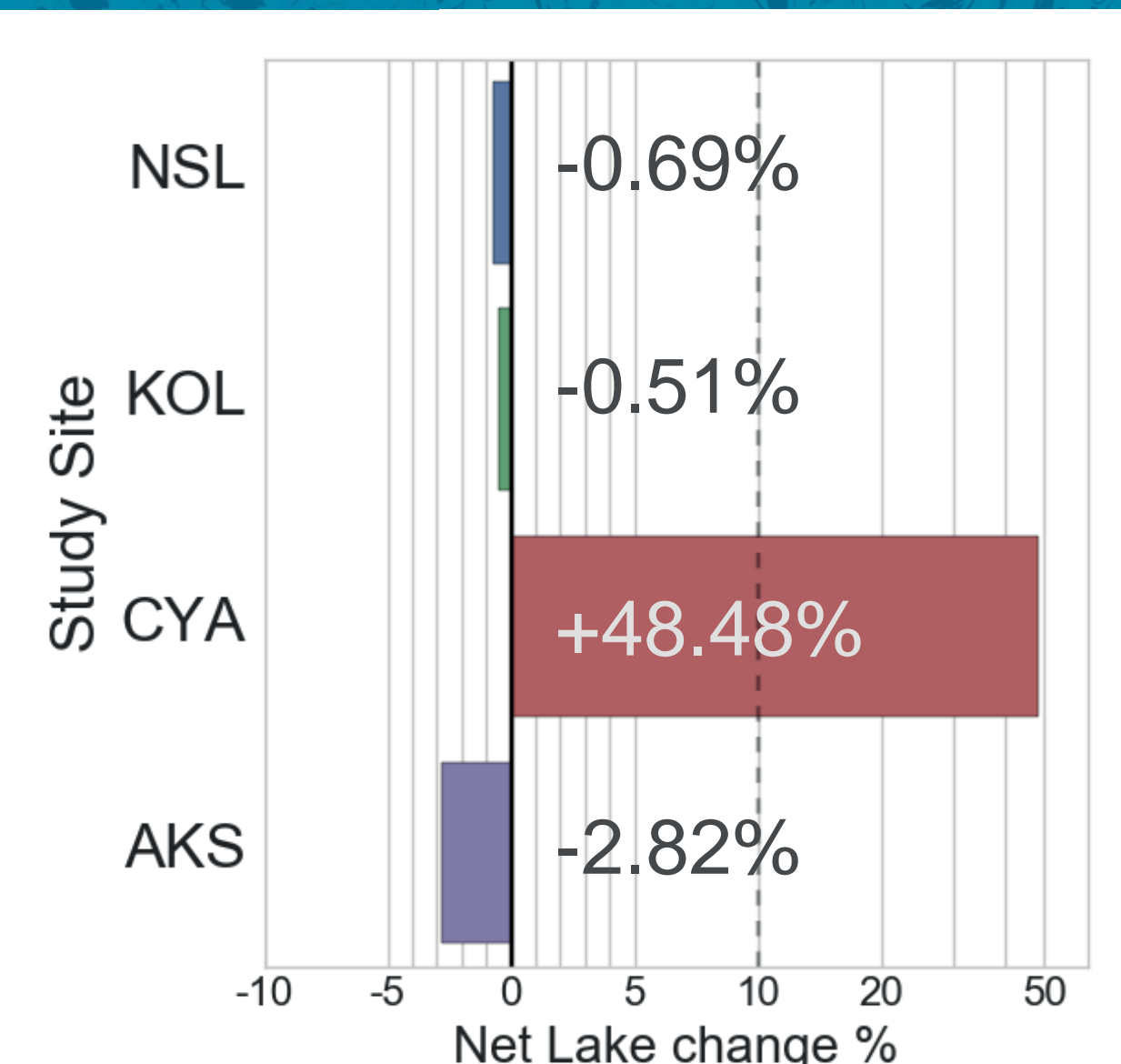


Figure 9: Diagram of Net lake changes for four study sites.

Conclusions

- Method for consistent lake change analysis in permafrost regions based on Landsat trends
- Diverse regional patterns of lake dynamics in permafrost regions
- Strong influence of local ground conditions on lake change direction and magnitude

For more detail please check our recent publication:

Nitze, I., Grosse, G., Jones, B. M., Arp, C. D., Ulrich, M., Fedorov, A., & Veremeeva, A. (2017). Landsat-Based Trend Analysis of Lake Dynamics across Northern Permafrost Regions. Remote Sensing, 9(7), 640.



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