ABoVE: Lake Growing Season Green Surface Reflectance Trends, AK and Canada, 1984-2019

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Dataset Version: 1

Summary

This dataset provides an annual time series of Landsat green surface reflectance and the derived annual trend during the growing season (June and July) for 472,890 lakes across the ABoVE Extended Study Domain from 1984 to 2019. The reflectance data are from Landsat-5, Landsat-7, and Landsat-8 sensors for the green band (center wavelength 560 nm). Over 270,000 Landsat scenes were evaluated and quality assured to be cloud-free and over water. Lakes were selected from HydroLAKES, a global database of lakes of at least 10 ha. Lake surface reflectance was extracted from a 3-by-3-pixel area centered on each lake centroid from the selected Landsat scenes determined from lake polygons. This dataset demonstrates changes in lake color over time in the arctic and boreal regions of North America. Color is relevant for understanding physical, ecological, and biogeochemical processes in some of the world's highest concentrations of lakes where climate change may have significant impacts.

There are two data files in text-delimited (*.txt) format; one with time series observations of growing season lake greenness for each lake for each year, and a second comprising the greenness trends and associated significance for each lake.

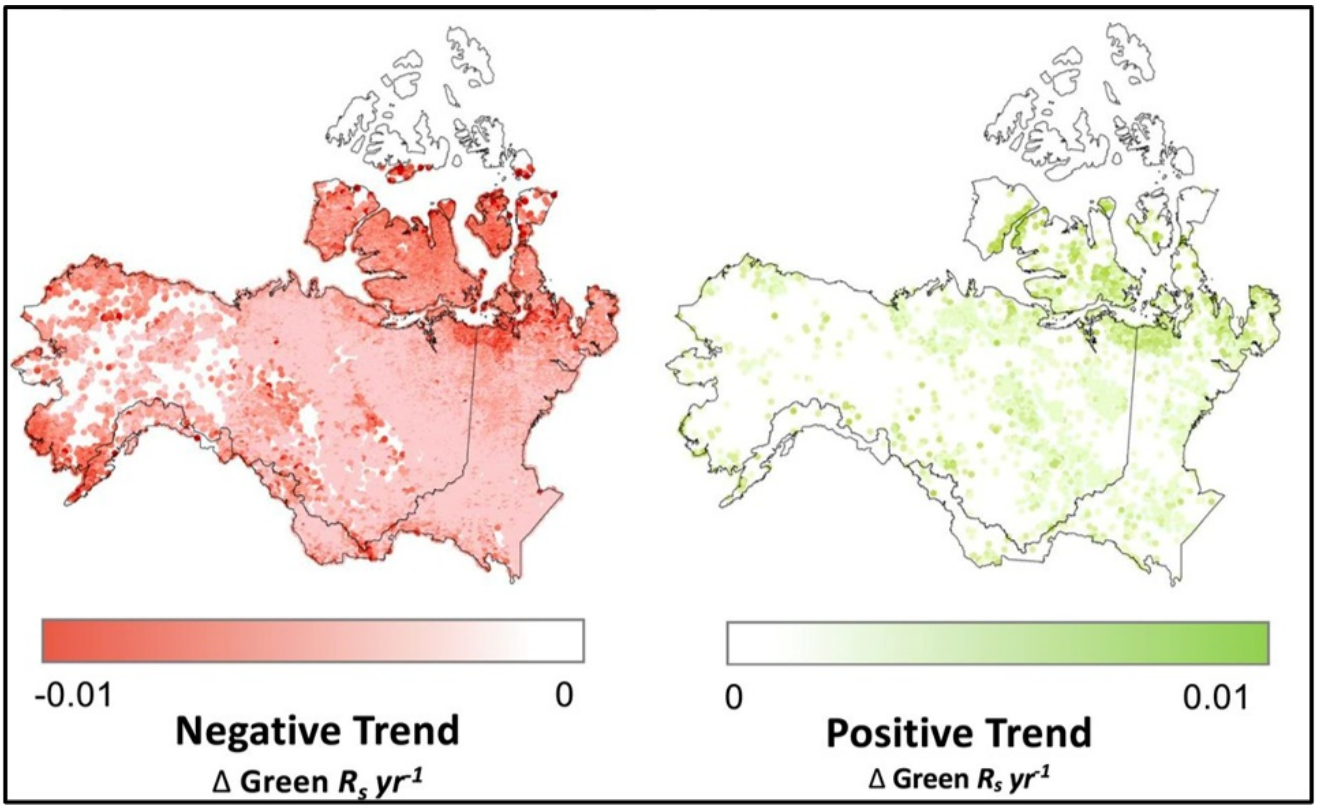

Figure 1. Lakes with significant (p<0.05) negative trends in "greenness" of lake surface reflectance (left) and positive trends (right) across growing seasons from 1984-2019 below 75 degrees N. Source: Kuhn and Butman, 2021

Citation

Kuhn, C., and D. Butman. 2021. ABoVE: Lake Growing Season Green Surface Reflectance Trends, AK and Canada, 1984-2019. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1866

Table of Contents

1. Dataset Overview

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Project: Arctic-Boreal Vulnerability Experiment

The Arctic-Boreal Vulnerability Experiment (ABoVE) is a NASA Terrestrial Ecology Program field campaign based in Alaska and western Canada between 2016 and 2021. Research for ABoVE links field-based, process-level studies with geospatial data products derived from airborne and satellite sensors, providing a foundation for improving the analysis and modeling capabilities needed to understand and predict ecosystem responses and societal implications.

Related Publication

Kuhn, C., and D. Butman. 2021. Declining greenness in Arctic-boreal lakes. Proceedings of the National Academy of Sciences 118:e2021219118. https://doi.org/10.1073/pnas.2021219118

Related Datasets

Messager, M.L., B. Lehner, G. Grill, I. Nedeva, and O. Schmitt. 2016. Estimating the volume and age of water stored in global lakes using a geo-statistical approach. Nature Communications 7. https://doi.org/10.1038/ncomms13603.

- HydroLAKES is a database aiming to provide the shoreline polygons of all global lakes with a surface area of at least 10 ha. Data are available at www.hydrosheds.org.

Loboda, T.V., E.E. Hoy, and M.L. Carroll. 2019. ABoVE: Study Domain and Standard Reference Grids, Version 2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1527

Acknowledgments

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2. Data Characteristics

Spatial Coverage: Alaska, U.S., and Alberta, British Columbia, Northwest Territories, Nunavut, Saskatchewan, and Yukon, Canada

> **ABoVE Reference Locations**
>
> Domain: Extended ABoVE (Laboda et al., 2019)
>
> State/Territory: Alaska and Canada
>
> Grid cells: Ah000v000, Ah000v001, Ah001v000, Ah001v001 Ah001v002, Ah002v000, Ah002v001, Ah002v002, Ah003v000, Ah003v001, Ah003v002, Ah003v003.

Spatial Resolution: Point locations

Temporal Coverage: 1984-07-01 to 2019-09-01

Temporal Resolution: Growing season (June-July) annual composites

Study Area: All latitudes and longitudes given in decimal degrees

Sites	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Alaska and Canada	-168.103	-81.2261	74.99945	49.54499

Data File Information

There are two data files in text-delimited (*.txt) format; one with time series observations of growing season lake greenness for each lake for each year, and a second showing the trends and associated significance for each lake. Each lake is identified by its HydroLAKES ID (Hylak_id).

User Note: The *.txt files are rather large. The time series data file has 14,130,886 observations and is 770 MB in size. The trends file has 472,889 observations and is 45 MB in size.

Table 1. File names and descriptions.

File Name	Description
trends_1984_2019_landsat_ABoVE_lake_greenness.txt	Annual trend and significance in lake growing season greenness from 1984-2019
time_series_landsat_ABoVE_lake_greenness_harmonised.txt	Annual average lake growing season greenness from 1984-2019

Data File Details

Table 2. Variables in the data file trends_1984_2019_landsat_ABoVE_lake_greenness.txt.

Column Name	Units	Description
continent		Continent where lake is located.
country		Country where lake is located

hylak_id		Unique lake identifier from the HydroLAKES dataset
latitude	Decimal Degrees	Latitude in decimal degrees of the lake centroid
longitude	Decimal Degrees	Longitude in decimal degrees of the lake centroid
sen_slope	Rs per year	The Sen slope is the change in unit of reflectance per year calculated by taking the median slope of all observations compared pairwise
mann_kendall_trend		Indicates whether the trend is significant at a p-value <0.05 and either increasing or decreasing. (no sig. trend, sig. decreasing, sig. increasing)
trend_significance		Significance (p-value) of slope
b2_mean		Mean Landsat growing season surface reflectance (Rs) in the green wavelengths averaged over the entire study period (1984-2019)
b2_std_dev		Standard deviation of Landsat growing season surface reflectance in the green wavelengths averaged over the entire study period (1984-2019)

Table 3. Variables in the data file time_series_landsat_ABoVE_lake_greenness_harmonised.txt.

Column Name	Units	Description
hylak_id		Unique lake identifier from the HydroLAKES dataset
date	YYYY-MM-DD	Growing season date. Set to July 1 of each year.
latitude	Decimal Degrees	Latitude in decimal degrees of the lake centroid
longitude	Decimal Degrees	Longitude in decimal degrees of the lake centroid
b2_mean		Mean Landsat growing season surface reflectance (Rs) in the green wavelengths averaged over that year's growing season
b2_std_dev		Standard deviation of Landsat growing season surface reflectance in the green wavelengths averaged over that year's growing season

3. Application and Derivation

This dataset is intended for evaluating changes in satellite lake color throughout the ABoVE domain. Satellite color is relevant for understanding physical, ecological, and biogeochemical processes in lakes.

4. Quality Assessment

This dataset was carefully quality controlled using a series of conservative filters to ensure only cloud-free pixels were used. At each lake centroid, the median, mean and standard deviation of the growing season surface reflectance in the green wavelengths (~560 nm) was calculated. The mean and standard deviation of green reflectance for each lake and the growing season mean and standard deviation per lake per year are provided in the data files (Kuhn and Butman, 2021).

5. Data Acquisition, Materials, and Methods

Overview

A time series and the annual trend in growing season (June-July) surface reflectance in the green wavelengths (~560 nm) was calculated for 472,890 lakes across the ABoVE domain from 1984 to 2019.

Landsat Data

Lake color was derived from Landsat observations from the Landsat-5, Landsat-7, and Landsat-8 sensors across the ABoVE domain (Fig. 2.). Landsat scenes acquired over the study domain (278,284 total scenes) were accessed through Google Earth Engine.

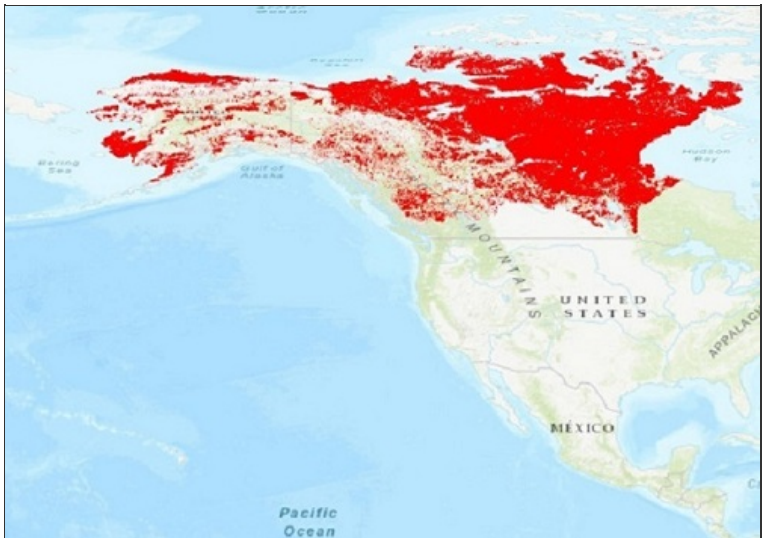

Figure 2. Study area (indicated in red) across the ABoVE domain.

Lake Greenness

Growing-season greenness for each lake was identified by sampling a 3-by-3 pixel area centered on each lake centroid calculated from HydroLAKES polygons within the study domain. HydroLAKES (Messager et al., 2016) is a dataset that includes lakes of at least 10 ha. The median, mean, SD, and pixel count of the green band inside each 3-by-3 pixel box were calculated for each lake at the native scale of the Landsat green band (30 m). Growing season greenness for each lake for each year was then exported for visualization and statistical analysis.

The dataset was further screened to exclude negative pixels (<1% of the dataset) and lakes with less than 10 years of data (2% of the dataset). To conservatively ensure that each observation was cloud-free and over water, a final filter using the Pixel QA ("pixel_qa") band was imposed to identify only lakes identified as cloud-free and water. Lake centroids were further intersected with the Global Surface Water Dataset (Pekel et al., 2016), and only those identified as having only permanent surface water ("transition_class"=1) inside the 3 × 3 grid were maintained in the dataset.

Time Series Analysis

To assess changes in lake surface reflectance over time, the final time series was created taking the average growing season reflectance, calculated as the average of Landsat scenes acquired during June-July based on precedent in the literature (Sulla-Menashe et al., 2018; Miles et al., 2019) and to avoid high cloud cover in August. Trends were calculated using Theil-Sen's Slope Estimator from the SciPy package (Jones et al., 2001), and slopes were tested for significance using a Mann–Kendall test, which is designed to identify monotonic trends and is been widely used to identify terrestrial greening and browning trends (de Jong et al., 2011). This nonparametric approach accounts for gaps in observation years.

Refer to Kuhn and Butman (2021) for details.

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

ABoVE: Lake Growing Season Green Surface Reflectance Trends, AK and Canada, 1984-2019

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

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