Remote Sensing of Water Quantity and Quality in Geospatial Education: Lake Sidney Lanier, GA, USA

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Clarence D. Brookins-Jackson, Zachary L. Boyd, Adam C. Freeland, Brittany L. Mann, M. Katherine Perry, Amber R. Ignatius

Institute for Environmental and Spatial Analysis, University of North Georgia

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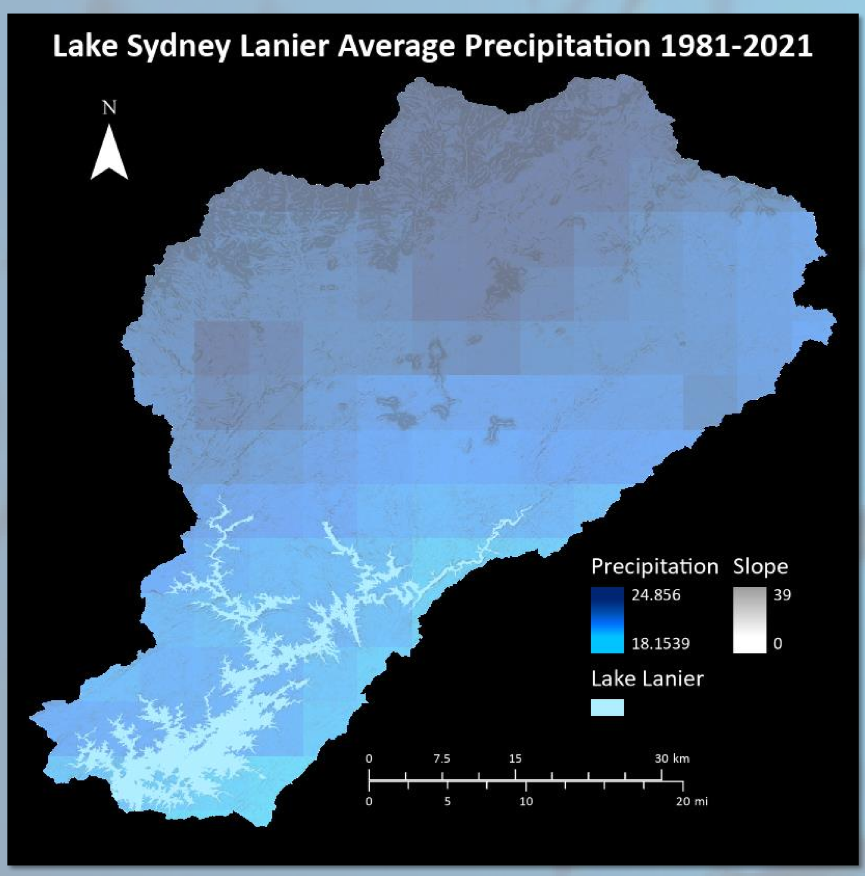
ABSTRACT

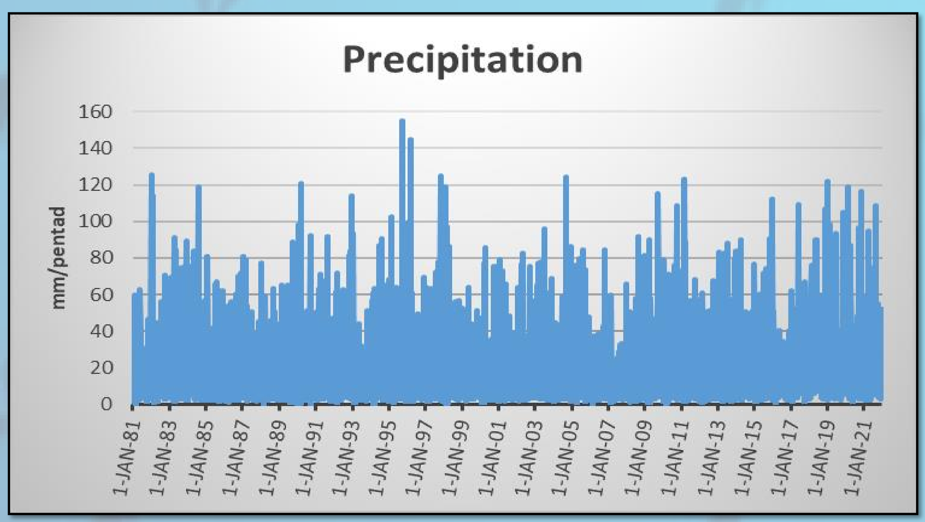
To increase geospatial awareness about local water resources, our team developed learning resources for the 150 km² Lake Sidney Lanier reservoir located in North Georgia, USA. The reservoir is vital for hydroelectric power generation, recreation, tourism, and consumptive uses. Using geospatial analysis in Google Earth Engine (GEE), we analyzed precipitation trends in the watershed using Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data. We also quantified expansion and contraction of reservoir surface area using Landsat-derived Global Surface Water data. As Lake Sidney Lanier is a managed reservoir, surface water extent fluctuations are related to climatic variables, consumptive use, and hydropower generation.

Water temperature varies based on seasonality, water depth, water clarity, and lake stratification. Changing temperature dynamics affect ecosystem health and determine other important water quality parameters such as dissolved oxygen concentrations. Landsat 8 Thermal Infrared Sensor (TIRS) data were used to examine temperature trends over multiple years and investigate the timing of lake stratification and mixing. Highly turbid waters are associated with pollutants and lower water quality and can affect ecosystem productivity by minimizing sunlight penetration into the water column. Sentinel 2 MSI data were processed using a turbidity algorithm to analyze temporal trends and spatial correlations with reservoir inflows. Finally, high concentrations of chlorophyll a were used as a proxy to identify harmful algal blooms. The spatial differences in headwaters and near-dam locations were examined and near real-time satellite data were explored for potential development of early-warning systems to protect ecosystem and human health.

PRECIPITATION

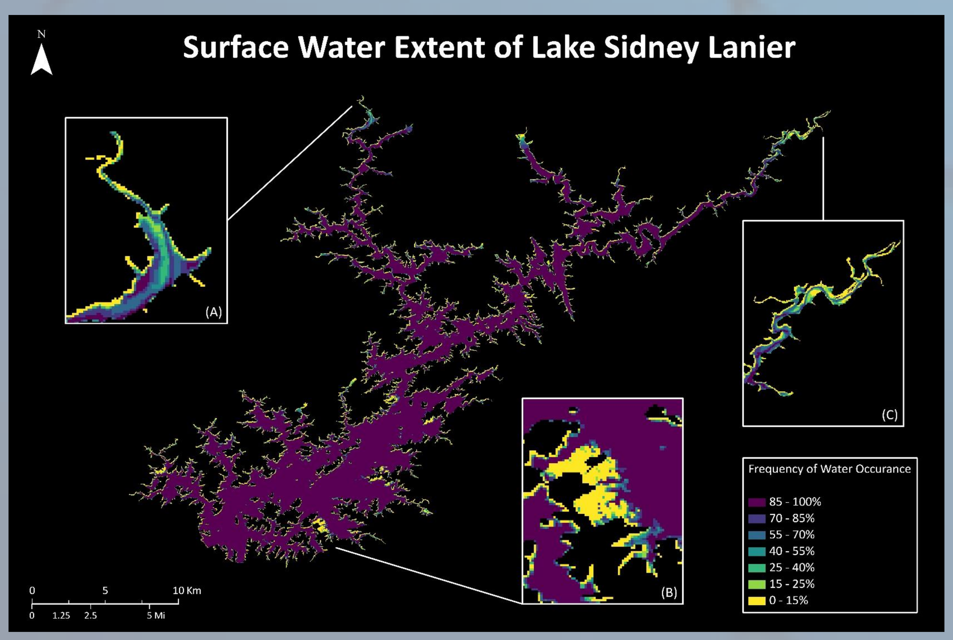


Water volume can alter water quality. Heavy rainfall can increase erosion into surface water sources, decreasing water quality, however increased water can dilute pollutants, increasing water quality. Lake Sydney Lanier, which supplies water to Atlanta and the surrounding area, has a relatively small watershed to support such a large population. For this map and chart, CHIRPS data gave rainfall values and WWF HydroSHEDS Void-Filled DEM provided the slope (Funk, et al. 2015, Lehner et al. 2008).

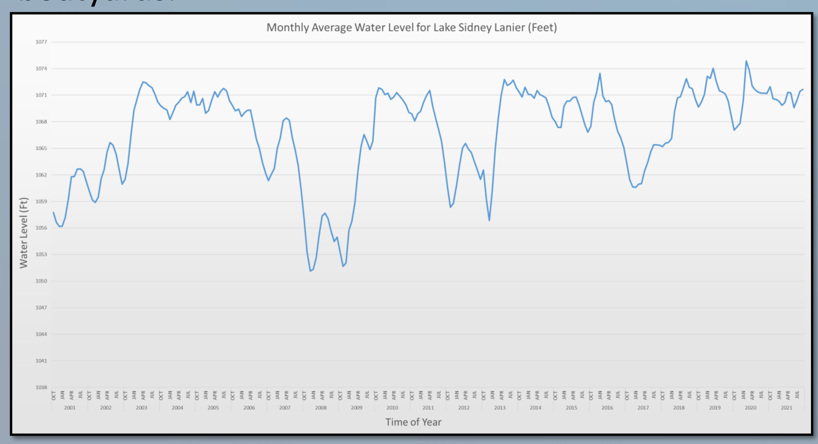


The map displays mean precipitation (1981-2021) for the Lake Sidney Lanier watershed. The time-series compares 5 day pentad precipitation values over a 40 year period.

SURFACE WATER EXTENT



Global Surface Water occurrence data shows how often each portion of the lake has water present in Landsat imagery during years 1984-2020 with 0% being never and 100% being always (Pekel et al., 2016). Portions of the lake with intermittent water occurrence is caused by drought periods and low water levels. In addition, 0% occurrence (such as inset (A) shown in the map above) may be due to mixed-pixel errors and the presence of docks and boatyards.



The graph displays lake water levels over twenty years from 2001 to 2021 (data obtained from U.S. Army Corps of Engineers). The 2007-2008 historical drought and other low-water periods in 2001-2002 and 2012-2013 are apparent.

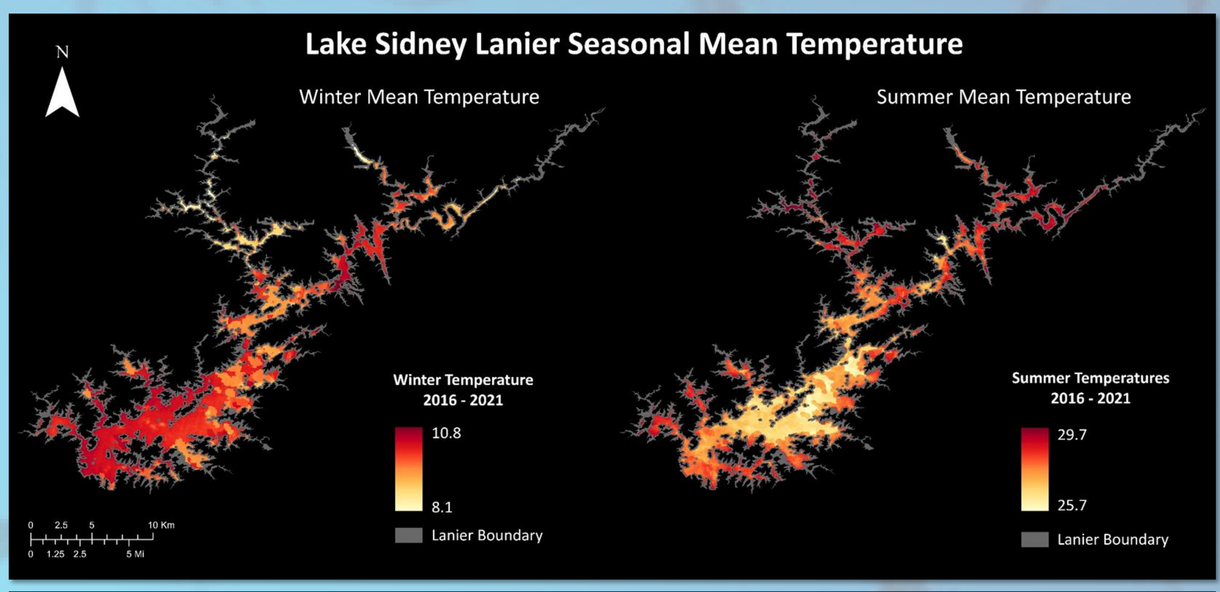
DATA SOURCES

Dataset	Source	Date Acquired	Spatial Resolution
Sentinel 2, surface reflectance	European Space Agency web:sentinels.copernicus.eu	4/2022	20m
Landsat 8, surface reflectance	USGS web:https://www.usgs.gov/landsat-missions/landsat-surface-reflectance	4/2022	30m
National Hydrography Dataset, Hydrologic Unit 8 – 03130001	USGS web:apps.nationalmap.gov/downloader	1/2022	1:24,000
Climate Hazards Group InfraRed Precipitation with Station Data. v2	University of California, Santa Barbara web:chc.ucsb.edu/data/chirps	3/2022	5566m
HydroSHEDS Void-Filled DEM	World Wildlife Fund US web:hydrosheds.org	4/2022	92.77m
Global Surface Water, occurrence data	European Commission web:global-surface-water.appspot	3/2022	30m

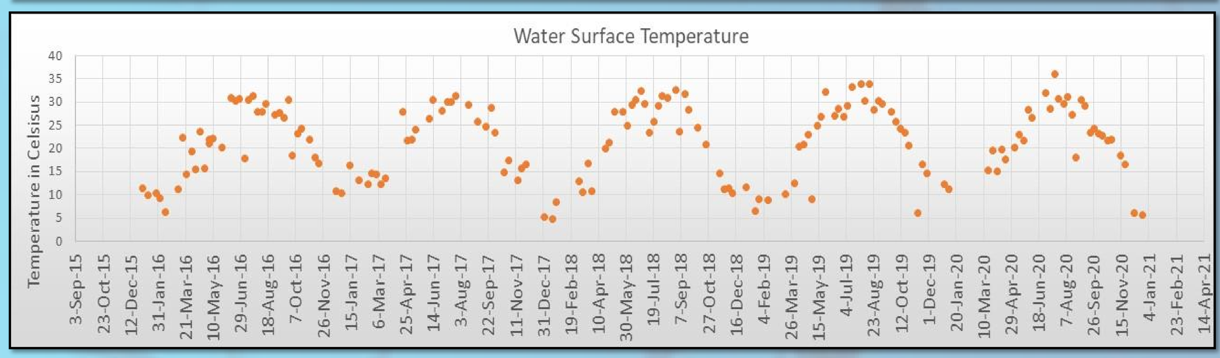

Lake Sidney Lanier in situ YSI sonde water sampling, March 2022

SURFACE WATER TEMPERATURE

Maps compare mean seasonal surface water temperatures for Lake Sidney Lanier based on Landsat 8 satellite band 10 surface reflectance data (Schaeffer et al., 2018). In winter, headwaters are relatively cool compared to near-dam locations. However, headwater mean temperature values are relatively warmer than near-dam surface waters in summer months.

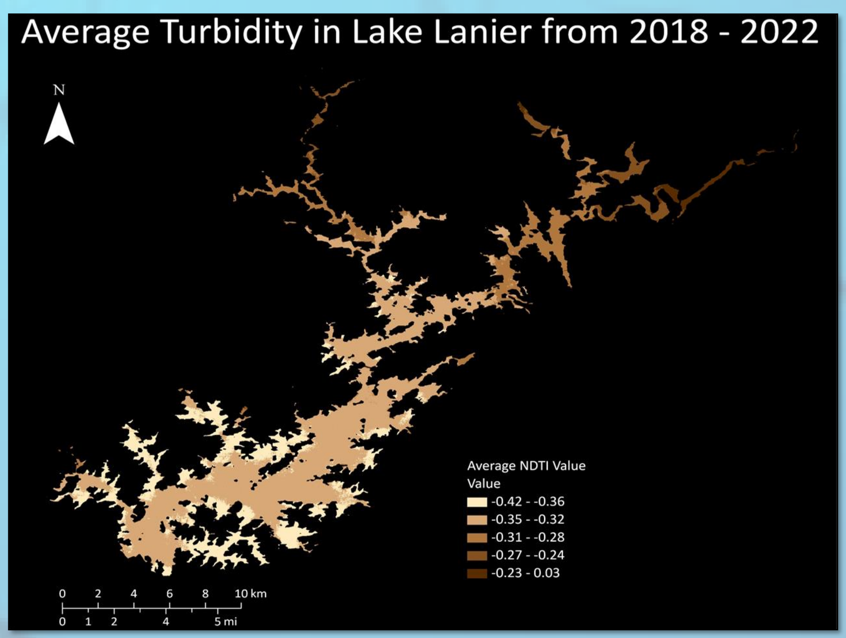


For each pixel, daily mean lake surface temperatures are displayed as time-series for years 2016-2020. For each location, mean surface temperature estimates indicate seasonal fluctuations are the dominant trend.

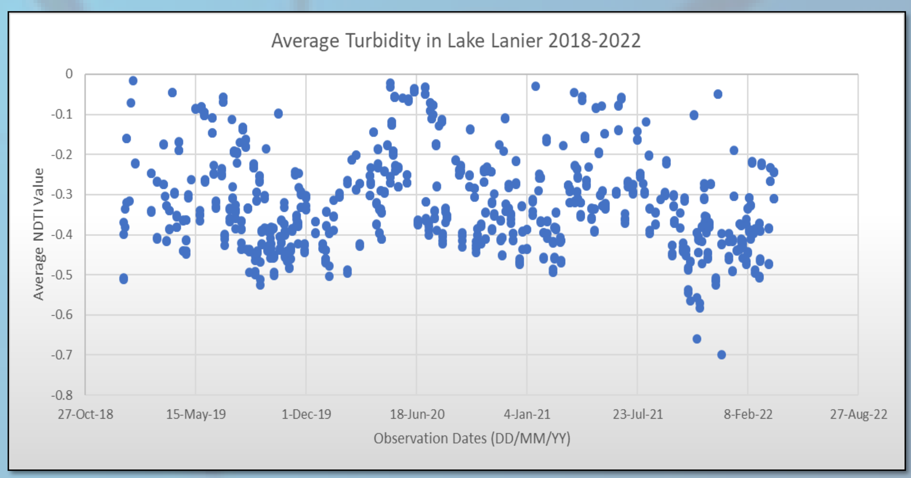


TURBIDITY INDEX

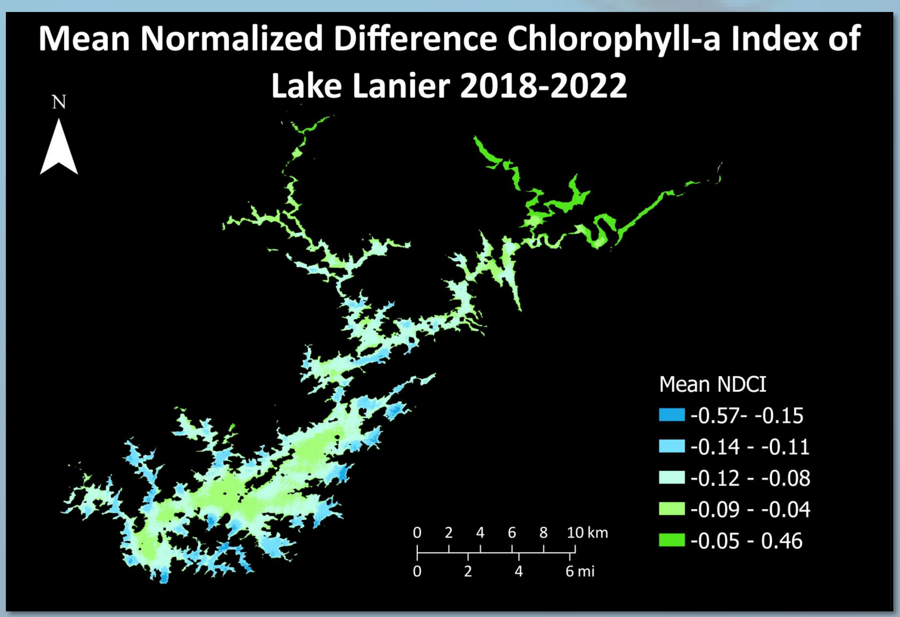
Sentinel 2 satellite imagery was processed to calculate normalized difference turbidity index (NDTI) per pixel (Lacaux et al., 2007). More than three years of observations (Dec 2018-Mar 2022) were processed to estimate mean NDTI during the study period. The map indicates mean NDTI is highest in headwaters in the northernmost section of the lake. The middle of the lake has higher satellite-derived mean NDTI levels than the surrounding branches, possibly due to wave action.



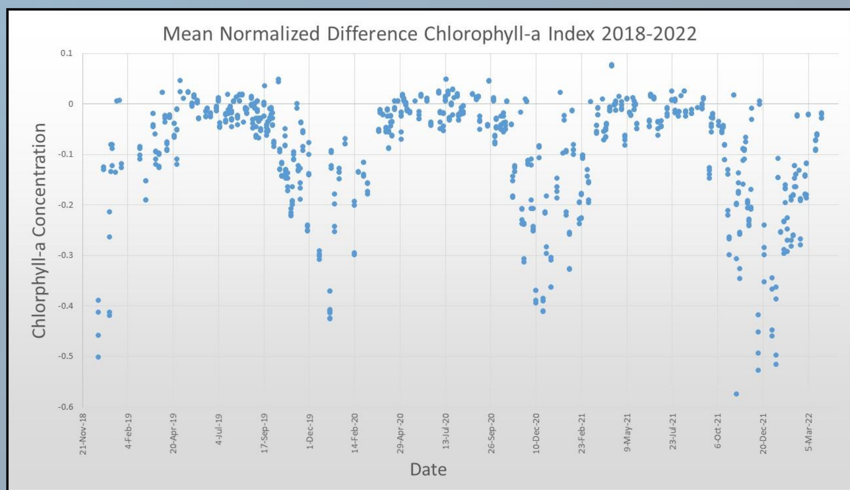
The mean daily NDTI time-series indicates high turbidity levels generally peak during late spring/early summer.



CHLOROPHYLL INDEX



Sentinel 2 MSI Imagery was used to calculate normalized difference chlorophyll-a index (NDCI) for a negative buffer of Lake Sidney Lanier (Lobo et. al., 2021). The lake contains relatively low NDCI values, but headwater locations display a higher mean NDCI.



NDCI time-series displays consistent spikes in warmer summer months and a plunge during the winter months.

EDUCATION - NSF AGET

As part of the ATE NSF grant, this project supports geospatial awareness among undergraduates and the broader community. Interactive maps and educational materials are provided online.

www.visualecogeo.com/iesa-ate


Lake Sidney Lanier, April 2021

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