



Environment and Natural Resources Trust Fund

2023 Request for Proposal

General Information

Proposal ID: 2023-106

Proposal Title: Providing Critical Water Temperature Data for Minnesota Lakes

Project Manager Information

Name: Leif Olmanson

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

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Project Basic Information

Project Summary: Create an automated system to acquire, process, and deliver new satellite-derived lake temperatures for all Minnesota lakes ~biweekly and make it available in the Minnesota LakeBrowser in near-real-time.

Funds Requested: \$297,000

Proposed Project Completion: June 30, 2026

LCCMR Funding Category: Foundational Natural Resource Data and Information (A)

Project Location

What is the best scale for describing where your work will take place?

Statewide

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

With warming temperatures, longer open water seasons, and more intense storms delivering more nutrients to our lakes, the occurrence of harmful algal blooms (HABs) and threats to fish habitats are increasing. Water temperature is one of the most important physical characteristics of aquatic systems, regulating many chemical and biological processes. Increasing water temperatures limit the fish habitat and increase the competitive advantage for cyanobacteria blooms. Lakes warm slower than air temperatures and the rate of warming depends on water clarity, lake depth, and size characteristics. Small shallow turbid lakes warm faster than large deep clear lakes. While water temperature measurements are relatively scarce, they are essential for determining lakes where high temperatures and associated low oxygen threaten fish habitats and where HABs are likely to occur. This type of information is critical for accessing fish habitats, identifying resilient systems, and guiding lake protection.

The project is a compelling opportunity to take advantage of archived and current data streams from operational satellites and the high-performance computing resources at the University of Minnesota. This proposal was designed to fill a void for high-resolution data to inform citizens, and lake management, including watershed protection and conservation of fish habitats.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

We will create an automated system delivering archived and frequent near real-time data and maps of lake temperature for all Minnesota Lakes. In previous LCCMR-supported projects, we have developed automated methods to expand remote sensing capabilities beyond water clarity to include chlorophyll (algae) and color. This project will apply those methods in a fully automated system that acquires, processes, and delivers satellite-derived lake water temperature and quality data as it becomes available (approximately biweekly). Citizens, government agencies, and researchers will have routine access to the data via an interactive web interface (Minnesota LakeBrowser <https://lakes.rs.umn.edu/>) linked to a spatial database that will operate at a nominal cost for years to come. This unique data source will dramatically improve data-driven resource management decisions and will inform the public about changing water temperature and quality conditions.

This project leverages:

- Pollution Control Agency and other existing monitoring programs to provide archived and ongoing lake temperature and water quality data for model calibration and validation;
- an automated water quality monitoring system developed in a 2018 LCCMR project that provides water quality data;
- lake temperature satellite products developed by the US Geological Survey EROS Data Center.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

This project will update the existing Minnesota LakeBrowser (<https://lakes.rs.umn.edu/>) to include lake temperature and implement near real-time water quality and temperature data capabilities for all of Minnesota's lakes. Online interactive maps for exploring Minnesota lake data will be regularly updated with new water quality and temperature data. High-frequency data will provide resource managers and lake associations with the information needed to fill gaps between sampling events and help identify waters for prioritization and implementation actions on the ground. Additionally, these data will cover a wide spatial area at a frequency that is unattainable by resource managers.

Activities and Milestones

Activity 1: Update automated water quality monitoring system with temperature and additional satellite products.

Activity Budget: \$190,000

Activity Description:

This project will modify the current water quality monitoring system to work with archive and ongoing Landsat products. This includes machine-to-machine access to U.S. Geological Survey servers for the acquisition of archived and current imagery to supply the demand for near real-time data. Newly acquired imagery will be sent through multiple scripted processing modules, which include (1) identifying and omitting contaminated pixels caused by clouds, cloud shadows, atmospheric haze, wildfire smoke, and specular reflection, and (2) classification of water pixels through a normalized difference water index to delineate an image-specific water mask. The combined masks result in qualified pixels which advance to develop models using routinely collected field temperature data to calibrate available temperature satellite products for Minnesota lakes. The temperature models will then be applied to all available clear archived 1985 to 2026 and ongoing Landsat 5, 7, 8, and 9 data to produce pixel and lake level databases of lake temperature.

Activity Milestones:

Description	Completion Date
Develop methods for 1985 to 2026 and ongoing Landsat temperature satellite products	June 30, 2024
Add temperature to the automated water quality monitoring system	June 30, 2025
Develop near real-time capability in the automated water quality and temperature monitoring system	December 31, 2025
Update database with over 40 years of archived and ongoing clarity, chlorophyll, color, and temperature	June 30, 2026

Activity 2: Develop near-real-time capability for water quality and temperature and adapt LakeBrowser to display archive and ongoing recent data

Activity Budget: \$107,000

Activity Description:

This project will update the Minnesota LakeBrowser with archived and current remotely sensed water quality and temperature data created in (Activity 1) and develop methods to utilize the near real-time capabilities to continually update the LakeBrowser with new data as it becomes available.

Activity Milestones:

Description	Completion Date
Add water quality and temperature data developed in Activity 1 to the LakeBrowser	June 30, 2025
Develop code to continually update the LakeBrowser with new data as it becomes available	December 31, 2025
Release fully operational and regularly updated Minnesota LakeBrowser	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
David Porter	Minnesota Supercomputing Institute, University of Minnesota	Scientific Computing Consultant who will implement the new satellite water quality and temperature models into the existing water quality monitoring system. He will also automate the system for ongoing near-real-time monitoring.	Yes
Peter Wringa	U Spatial, University of Minnesota	(GIS and online web development) developed the code for the current LakeBrowser and will add the new water quality and temperature data to the LakeBrowser. He will also add the capacity for regular updates as new data becomes available.	Yes

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

Semi-automated computer code will routinely acquire the latest satellite imagery and provide lake water quality and temperature data. Information will be freely available to all through the Minnesota LakeBrowser. Maintenance to the Minnesota LakeBrowser and any updates to data processing would be funded by pursuing funds from data users.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Assessment of Surface Water Quality With Satellite Sensors	M.L. 2016, Chp. 186, Sec. 2, Subd. 04i	\$345,000
Providing Critical Water-Quality Information for Lake Management	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 03b	\$250,000

Project Manager and Organization Qualifications

Project Manager Name: Leif Olmanson

Job Title: Researcher 6

Provide description of the project manager's qualifications to manage the proposed project.

Leif Olmanson will oversee the overall management of the project and has had experience co-managing previous LCCMR projects and managing other projects. He has over 25 years of experience developing remote sensing applications to create temporally and spatially rigorous datasets of water and land resources for large area ecosystem characterization. He is particularly interested in developing field-validated image processing methods implemented in automated geospatial analysis systems such as Google's Earth Engine and Minnesota Supercomputing Institute supercomputers to gain a better understanding of the natural environment. He has led a team of researchers and computer scientists to build an automated water quality monitoring system for Minnesota's >10,000 lakes using satellite imagery to provide critical water quality information for citizens and lake management. And oversaw the modifications of the Minnesota LakeBrowser with new capability to take advantage of the high volume of data provided by the automated system.

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

Organization Description:

All personnel are based at the University of Minnesota, one of the largest, most comprehensive, and most prestigious

public universities in the US (<https://twin-cities.umn.edu/>). The labs and offices of the investigators and collaborators are equipped with the necessary space and facilities needed for the proposed work.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
PI, Leif Olmanson		Research Scientist			26.7%	1.35		\$138,142
Co-PI, David Porter		Scientific Computing Consultant			26.7%	0.6		\$103,383
Co-PI, Peter Wiringa		Geospatial Analyst, Web Design			26.7%	0.39		\$50,987
							Sub Total	\$292,512
Contracts and Services								
University of Minnesota Remote Sensing Laboratory	Internal services or fees (uncommon)	Access to remote sensing/GIS software and computers for model development at the University of Minnesota.				0		\$2,400
							Sub Total	\$2,400
Equipment, Tools, and Supplies								
							Sub Total	-
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Conference Registration	1 to 2 conferences (in state) per year, UMN (registration, mileage, per diem per UMN policies)	Present results of LCCMR-funded work.					\$2,088

	Miles/ Meals/ Lodging							
							Sub Total	\$2,088
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$297,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 55% modified total direct costs.	Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs)	Secured	\$163,522
In-Kind	United States Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center	Value of Landsat satellite imagery from EROS Center. The estimated net value of Landsat imagery over the project period is \$326,400 (~544 images X \$600/per image).	Secured	\$326,400
			Non State Sub Total	\$489,922
			Funds Total	\$489,922

Attachments

Required Attachments

Visual Component

File: [5a331252-b1e.pdf](#)

Alternate Text for Visual Component

Indicates that water temperature is one of the most important physical characteristics of aquatic systems, regulating many chemical and biological processes such as limiting fish habitat and increasing the competitive advantage for harmful algal blooms. Shows workflow of automated lake water quality and temperature system that this project will develop....

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have potential for royalties, copyrights, patents, or sale of products and assets?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Providing Critical Water Temperature Data for Minnesota Lakes

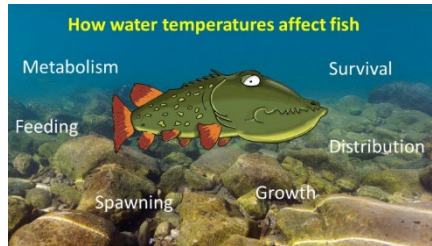
Goals: This project adds **lake temperature** to the **Minnesota LakeBrowser** by modifying an existing **automated** water quality monitoring system to process **satellite** data for the lake temperature of Minnesota's 10,000+ lakes in **near real-time**.

- It will provide a current and **historic record** of easy-to-use, strategic information to inform citizens and **improve lake management and fish habitat**.

Background: Water temperature is one of the most important physical characteristics of aquatic systems, regulating many chemical and biological processes.



Harmful Algal Blooms



Fish Habitat

Increasing water temperatures limit the fish habitat and increase the competitive advantage for harmful algal blooms.

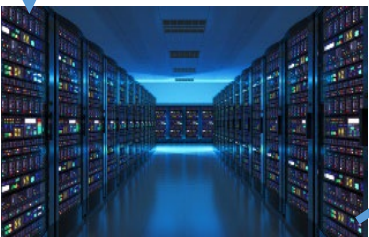
Applications: Lake temperature information is important for citizen recreational use, accessing fish habitats, identifying resilient systems, and guiding lake protection.

Approach

- EROS Data Center



Automated satellite imagery pipeline



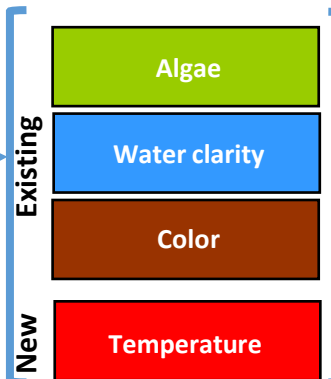
UMN high performance computing systems



Landsat Satellites
Thermal Data
1985 to current

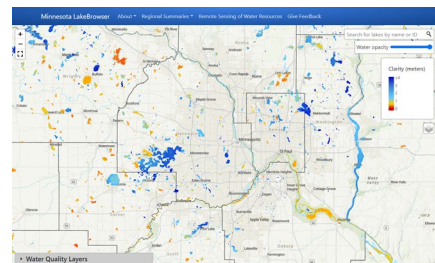
Normalize images
Remove land, clouds, shadows, haze...

Prepare images using new automated methods.



Apply temperature models

Maps, data, statistical



Minnesota LakeBrowser
<https://lakes.rs.umn.edu/>



Provide information to agencies, researchers, and citizens.

