Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-539

Proposal Title: Ice on the Lake

Project Manager Information

Name: Lian Shen

Organization: U of MN - St. Anthony Falls Laboratory

Office Telephone: (612) 624-2022

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Project Basic Information

Project Summary: This project develops precise predictive models for the ice dynamics and water waves to enhance safety, protect critical infrastructure, and support sustainable economic activities in Minnesota's lakes, particularly Lake Superior.

ENRTF Funds Requested: $529,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Water (B)

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.

Lake Superior is vital to Minnesota's economy, environment, and quality of life. It contains nearly 10% of the world's surface freshwater and anchors critical industries through the Great Lakes-St. Lawrence navigation system. Each year, the Duluth-Superior port alone handles roughly 32 million tons of cargo, underpinning essential sectors like mining, steel, energy, and trade. However, severe winter conditions significantly disrupt shipping from December through March, halting critical economic activities and posing safety risks due to ice floes and harsh weather. These disruptions extend beyond commercial shipping, affecting Minnesota's thriving recreational boating industry, which generates over $1 billion annually. Furthermore, in the numerous lakes throughout Minnesota, ice shoving damages shoreline infrastructure, and prolonged ice cover has a negative impact on aquatic ecosystems. Unfortunately, current forecasting models fail to adequately predict winter lake conditions, resulting in suboptimal economic decisions and increased infrastructure vulnerability. For example, NOAA's existing Great Lakes wave prediction systems oversimplify ice dynamics, resulting in inaccurate predictions of wave heights, ice movement, and collision risks. Developing advanced, Minnesota-tailored predictive models for lake ice is essential. Improved forecasts will protect economic interests, enhance safety, safeguard infrastructure, and ensure the sustainable management of Minnesota's critical freshwater resources.

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.

Our objective is to develop an accurate, user-friendly model for predicting ice floe movements and water waves in Lake Superior and other large freshwater bodies in Minnesota. The advanced model will specifically address the unique challenges posed by lake seiches and wind-driven waves in ice-covered conditions in Minnesota. By integrating satellite-based ice floe size distribution data, validated against historical and recent observations, we will perform robust three-dimensional numerical simulations. These simulations will enhance ice forecasting capabilities, providing critical insights into ice dynamics and wave interactions with ice. Our model will serve as the basis for a software tool designed to predict large-scale ice floe movements and wave activity. This solution will directly benefit local communities, commercial shipping, recreational activities such as ice fishing, and emerging offshore energy projects by mitigating risks, including ice shoving, structural damage, and energy inefficiencies. Continuous model validation through satellite remote sensing will ensure accuracy and reliability, allowing real-time updates and adaptive responses to variable ice and weather conditions across Lake Superior. Our project will empower Minnesota policymakers and stakeholders with a vital tool for informed decision-making, infrastructure protection, and economic resilience.

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?

The specific outcomes of this project directly support Minnesota's public purpose of protecting, conserving, preserving, and enhancing the state's natural resources by providing an accurate forecasting model for ice cover, wave heights, and ice floe movements in freshwater bodies, particularly Lake Superior. Enhanced predictions will safeguard shoreline infrastructure, minimize environmental impacts from ice-induced incidents, and reduce hazards to vessels and offshore structures. Improved forecasts will enable more effective management and conservation of aquatic ecosystems and optimize commercial and recreational activities that depend on ice conditions, such as ice fishing.

Activities and Milestones

Activity 1: Utilize multi-source satellite data and leverage artificial intelligence (AI) to develop a comprehensive online inventory of lake-ice phenology for Minnesota

Activity Budget: $150,000

Activity Description:
This research activity will leverage multi-source satellite data and artificial intelligence (AI) to develop a comprehensive, Geographic Information Systems (GIS) based online inventory of lake-ice phenology for Minnesota. By integrating optical and radar imagery from satellites like Sentinel-1, Sentinel-2, and Landsat, the study aims to monitor seasonal ice formation, duration, thickness, and breakup across diverse lake ecosystems. AI algorithms will be trained to process large datasets, automatically detecting ice cover changes with high accuracy despite challenges like cloud cover. The resulting phenological data—such as freeze-up and ice-off dates—are geospatially mapped using GIS, providing a dynamic, publicly accessible online platform. This inventory enables researchers, policymakers, and local communities to track long-term trends in lake-ice dynamics and plan for safe recreational activities. By combining AI-driven automation with multi-satellite observations, this initiative offers a scalable, cost-effective solution for real-time environmental monitoring, supporting ecological studies, water resource management, and climate adaptation strategies across Minnesota's lake-rich landscape.

Activity Milestones:

Description	Approximate Completion Date
Data collection and pre-processing	June 30, 2027
AI development and testing	December 31, 2027
GIS platform development and testing	June 30, 2028
Dissemination of the results through peer-reviewed publications	December 31, 2028

Activity 2: Comprehensive data collection and validation of ice floe dynamics

Activity Budget: $100,000

Activity Description:
The primary objective of Activity 1 is to acquire comprehensive and high-quality data critical for accurately modeling ice floe dynamics and wave interactions on Lake Superior. We will systematically compile and analyze historical and current satellite imagery, integrating it with recent remote-sensing datasets to create an extensive database of ice floe distributions, sizes, and trajectories across various seasonal conditions. We will focus on critical periods—early freezing in winter and thawing in spring—when ice conditions pose maximum risk to navigation and infrastructure. The datasets will be used to test our predictive model, significantly enhancing forecast reliability and stakeholder confidence.

Activity Milestones:

Description	Approximate Completion Date
Compilation and initial analysis of historical satellite data	August 31, 2027
Conduct fall freezing season data synthesis	January 31, 2028
Conduct spring thaw season data synthesis	May 31, 2028
Complete final validation and comprehensive dataset preparation	September 30, 2028

Activity 3: Development of an advanced numerical predictive model for lake ice

Activity Budget: $150,000

Activity Description:
We will develop a sophisticated three-dimensional numerical model tailored specifically for freshwater ice conditions, wave-ice interactions, and ice floe movements on Lake Superior. The model will integrate detailed ice dynamics, localized wave characteristics, and freshwater ice properties (which differ substantially from those of sea ice) to significantly improve forecast accuracy beyond existing ice modeling capabilities. Leveraging the validated datasets from Activities 1 and 2, our modeling efforts will emphasize precision, computational efficiency, and usability, enabling accurate real-time and predictive scenario analyses. Rigorous testing will utilize extensive historical and current datasets, allowing comprehensive evaluation and iterative refinements of model algorithms and parameters. This iterative refinement process ensures the resulting predictive model is robust, reliable, and practical for end-users, including policymakers, maritime operators, recreational businesses, and infrastructure managers.

Activity Milestones:

Description	Approximate Completion Date
Complete initial model development and preliminary testing	June 30, 2028
Finalize comprehensive model testing and refinement with historical and current data	December 31, 2028
Deliver an operational predictive model fully calibrated for Lake Superior conditions	March 31, 2029

Activity 4: Forecasting software development, implementation, and stakeholder engagement

Activity Budget: $129,000

Activity Description:
The goal of Activity 4 is to develop and deploy user-friendly forecasting software that incorporates our validated numerical model. This software will deliver timely and easily interpretable predictions to diverse stakeholders, including policymakers, ship operators, recreational boating and fishing communities, and renewable energy developers. We will design the software interface to be accessible to non-technical users, enabling them to make effective decisions, manage risks, and plan operations. We will host interactive workshops and stakeholder training sessions across Minnesota's Lake Superior communities to demonstrate software capabilities, provide user training, and gather valuable feedback for continuous improvement. Through this extensive engagement process, stakeholders will directly inform final software enhancements, maximizing practical utility and ensuring broad adoption and beneficial impact across the region.

Activity Milestones:

Description	Approximate Completion Date
Release functional forecasting software prototype and initiate beta-testing with selected stakeholders	March 31, 2028
Conduct interactive stakeholder workshops, comprehensive training, and feedback collection sessions	December 31, 2028
Deploy fully operational software and publicly disseminate through online platforms and community forums	June 30, 2029

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?

Project results, including the forecasting model and software tool for lake ice, will be integrated into existing operational frameworks for research and operations, ensuring continued usage and maintenance beyond the project timeline. Publicly accessible software will enable ongoing benefits to Minnesota communities, policymakers, and stakeholders. Future enhancements and necessary updates will be pursued through federal grants, state programs, and industry partnerships. The University of Minnesota's St. Anthony Falls Laboratory is committed to providing ongoing technical support and stakeholder training, thereby fostering sustainable implementation and maximizing the project's long-term impact on environmental stewardship, economic resilience, and public safety statewide.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Remote Sensing And Super-Resolution Imaging Of Microplastics	M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 08j	$309,000
Fate of Minnesota's Lakes in the Next Century	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 03d	$453,000
Hyperspectral Characterization of Toxic Harmful Algal Blooms	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 04a	$399,000

Project Manager and Organization Qualifications

Project Manager Name: Lian Shen

Job Title: Professor and Director

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

Dr. Lian Shen is a Distinguished McKnight University Professor at the University of Minnesota. He also holds the Kenneth T. Whitby Professorship in the Department of Mechanical Engineering and serves as the Director of the St. Anthony Falls Laboratory. He earned his Doctor of Science degree from Massachusetts Institute of Technology in 2001. After postdoctoral training at MIT, he joined the faculty of Johns Hopkins University in 2004. In 2012, he was recruited by the University of Minnesota to join its faculty. Dr. Shen is a world expert in the research of environmental fluid flows and renewable energy, with more than 150 papers published. He is also a member of the editorial boards of five internal academic journals. Dr. Shen has organized several national and international conferences and symposiums and has participated in many research projects funded by federal and state agencies.

Dr. Ardeshir Ebtehaj will be responsible for analyzing climate models using statistical and web-based tools to make the project results accessible to stakeholders. He has studied remote sensing and climate change impacts on rain, snow, and clouds for nearly 20 years. He has conducted peer-reviewed research in satellite remote sensing and climate change impacts on precipitation, clouds, soil moisture, lakes, vegetation, snow, and plastic pollution in freshwater ecosystems. He has served as the Principal Investigator for numerous NASA projects and three LCCMR projects. He has published over 55 peer-reviewed papers. Dr. Ebtehaj is an editor of the Journal of Hydrometeorology and a member representative of the University of Minnesota in the University Centers for Atmospheric Research (UCAR). He received an editor award from the American Meteorological Society, NASA's Earth and Space Science Fellowship in 2014, and NASA's New Investigator (Early Career) award in 2018 for his contributions to Earth's remote sensing sciences.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:

This project will be performed at the St. Anthony Falls Laboratory (SAFL, http://www.safl.umn.edu) at the University of Minnesota. SAFL is an interdisciplinary fluid mechanics research and educational center. It has 22 faculty members and 27 research and administrative staff members. Each year, more than 100 postdocs and students conduct research at SAFL. SAFL is a world-renowned research laboratory specializing in environmental, geophysical, and engineering fluid mechanics. SAFL researchers have conducted numerous innovative environmental studies in Minnesota. Some of the projects were/are funded by the Minnesota Environment and Natural Resources Trust Fund. The proposed research leverages the unique and advanced capabilities of simulating and measuring environmental and geophysical flows at SAFL, which has 16,000 square feet of research space dedicated to research.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project Manager		Oversee the whole project, supervise the research team, lead the research, and responsible for project reporting			26.8%	0.12		$40,348
Postdoctoral Associate		Design and establish computational model and carry out computer simulations			20.2%	3		$244,531
Graduate Student Research Assistant		Perform remote sensing study to validate the computational model			18.8%	1.5		$177,050
Undergraduate Student Assistant		Assist data analysis and model validation			0%	0.18		$6,120
Computer Scientist		Assist computational model development			24.4%	0.24		$25,090
Co-investigator		Perform remote sensing based research			26.8%	0.12		$30,744
							Sub Total	**$523,883**
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
							Sub Total	-
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-

Travel In Minnesota								
							Sub Total	**-**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Publishing fee for papers reporting results of this project	Publishing fee for papers reporting results of this project. Estimated at $1000/paper for four papers.					$4,000
							Sub Total	**$4,000**
Other Expenses								
		Non-capital equipment	Computer data storage for archiving the data of this project					$1,117
							Sub Total	**$1,117**
							Grand Total	**$529,000**

Classified Staff or Generally Ineligible Expenses

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

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	Unrecovered F&A	Support of SAFL facilities where research will be conducted.	Secured	$256,496
			Non State Sub Total	**$256,496**
			Funds Total	**$256,496**

Total Project Cost: $785,496

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 28dc3857-f93.pdf

Alternate Text for Visual Component

It highlights lake ice data collection through remote sensing and AI. The data will be used to validate the ice-floe dynamics. Utilizing computer simulations to develop a prediction model for safer navigation, outdoor recreation, and ice-shoving events. Ensuring seamless software deployment and fostering community engagement to share insights effectively....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Letter of University of Minnesota SPA	ddb3d39b-34a.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

N/A

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

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

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care,

treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Victoria Troxler

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A