Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-497

Proposal Title: Guiding Minnesota Climate Resilience: Actionable Surface Temperature Insights

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: This project uses advanced modeling and satellite data to map Minnesota's surface and subsurface temperatures, helping farmers, resource managers, and Tribes mitigate heat stress and reinforce climate-resilient strategies.

ENRTF Funds Requested: $584,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Resiliency (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.

Minnesota's ecosystems and communities are experiencing climate change in locally specific and environmentally significant ways. Shifting growing seasons, heavier rainfall, prolonged drought, and rising temperatures are reshaping landscapes, stressing forests and prairies, degrading soil health, and threatening freshwater systems. Because impacts vary widely across the state, place-based understanding is essential for effective climate resilience planning.

Terrestrial surface temperature, distinct from air temperature, is a critical but often overlooked indicator. It influences soil moisture loss, crop and forest health, pest emergence, fertilizer efficiency, and agricultural productivity. Surface temperature also affects water quality by increasing runoff temperatures that fuel algal blooms, altering evapotranspiration, and amplifying heat-island effects in urban and rural areas. Yet many Minnesota communities lack access to accurate, calibrated surface-temperature data needed for land-use and environmental decisions.

This project combines advanced modeling, historical and current satellite observations, and high-performance computing at the University of Minnesota to produce localized insights into surface-temperature patterns. By translating complex environmental signals into practical tools, we aim to support communities facing ecological degradation, agricultural challenges, and temperature-related risks. Through targeted, data-driven guidance, Minnesota can better protect its natural resources and strengthen long-term ecological and agricultural resilience.

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.

This project will address a significant knowledge gap in understanding how ground surface temperatures vary across Minnesota, driven by factors such as latitude, prevailing weather systems, land cover, and land-use practices. While statewide climate trends are well-documented, localized effects, such as urban heat islands and bare agricultural soil, often receive less attention yet play a crucial role in shaping regional temperature patterns and hydrologic responses.

To tackle this, we will use thermal data from the Landsat program, along with other relevant datasets, to conduct a comprehensive analysis of surface temperature trends in Minnesota from 2013 to 2030 at a 100-meter spatial resolution. We will analyze the relationships between surface temperatures, weather patterns, and land-use scenarios. To do this, we will incorporate weather data, soil properties, and watershed data from the University of Minnesota's GEMS Exchange APIs including key ground-sensed data made available to us by the Minnesota Department of Agriculture (MDA).

Employing advanced machine learning techniques, we will develop predictive models for subsurface and forecasting temperatures, enabling an assessment of the potential impacts of warming on local environments. Our research aims to provide valuable insights into Minnesota's evolving surface temperature landscape, accounting for both natural and human-induced factors.

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?

- Seventeen-year-long real-world comprehensive database of Minnesota statewide satellite-derived surface temperature data (2013-2030).
- Seventeen-year-long comprehensive database of modeled Minnesota statewide subsurface and forecast temperature data similar to a weather forecast (2013-2030).
- Incorporate summary results into an interactive surface temperature visualization tool.
- Develop and deliver information and data to support agricultural and natural resource managers and Tribes to better understand and manage surface temperature hot spots to target mitigation strategies to improve the health of

Minnesota's managed ecosystems.

- Develop tools to access these data from the GEMS Exchange using ArcGIS Pro and QGIS.

Activities and Milestones

Activity 1: Modify the existing automated satellite remote sensing system to provide 17 years of statewide Minnesota temperature data.

Activity Budget: $180,000

Activity Description:
Modify the current water quality monitoring system hosted at the University of Minnesota's Supercomputing Institute to refactor Landsat-derived land surface temperature products, enabling comprehensive thermal analysis across terrestrial environments. This enhancement will enable automated machine-to-machine access to U.S. Geological Survey (USGS) servers to streamline Landsat imagery acquisition. Retrieved imagery will pass through a series of scripted processing modules designed to improve data quality and ensure scientific rigor.

First, quality-control algorithms will identify and exclude contaminated pixels affected by clouds, cloud shadows, atmospheric haze, wildfire smoke, cirrus cloud displacement, and specular reflection. Next, calibrated thermal bands will be converted into more accurate land surface temperature measurements using established radiometric correction procedures.

Calibration and validation of machine learning models will utilize regularly collected in situ temperature observations to enhance accuracy and regional relevance, specifically for Minnesota's environmental conditions. This integration of field data will refine satellite-derived temperature estimates and reduce systematic bias.

Once validated, the updateable surface temperature models will be applied to all available clear-sky Landsat 8 and Landsat 9 imagery from 2013 through 2030. The result will be a consistent, long-term archive of Landsat-based temperature observations to support environmental monitoring, climate analysis, and resource management applications.

Activity Milestones:

Description	Approximate Completion Date
Develop methods for the Landsat temperature satellite products	December 31, 2027
Add temperature to the automated monitoring system	June 30, 2028
Develop and apply Machine Learning temperature models	December 31, 2028
Compile the temperature database for 2013 to 2029	December 31, 2029

Activity 2: Developing, calibrating, and validating ground surface and subsurface temperature models informed by weather data and direct measurement.

Activity Budget: $294,000

Activity Description:
Developing, calibrating, and validating ground-surface and subsurface temperature models involves a sophisticated integration of meteorological data with satellite-based thermal observations. This integration is essential for accurately representing heat dynamics across diverse landscapes. Key weather inputs, such as air temperature, solar radiation, wind speed, humidity, and precipitation, drive physically based energy-balance and heat-transfer models that simulate how heat is absorbed, conducted, stored, and released at the land surface and within subsurface layers.

Calibration involves fine-tuning model parameters, such as soil thermal conductivity, heat capacity, surface albedo, and moisture content, to ensure that simulated temperatures closely match observed data. Utilizing Landsat's thermal

infrared sensors, we obtain spatially distributed land surface temperature (LST) estimates for comparison across various land cover types. Subsurface validation incorporates in-situ temperature probes for accurate assessment below ground.

Validation employs independent datasets and statistical metrics such as RMSE, MAE, and R^2 to gauge predictive accuracy. The combination of remote sensing and ground-based data improves spatial coverage, reduces uncertainties, and enhances model reliability. These validated models are vital for applications in environmental stewardship, agriculture, forestry, water resources, and infrastructure planning, including optimizing best management practices, the prediction of algal blooms, and the assessment of urban and rural heat islands.

Activity Milestones:

Description	Approximate Completion Date
Develop weather-informed surface and subsurface temperature models	March 31, 2028
Apply surface and subsurface temperature models	June 30, 2028
Test models, calibrate, and validate with available temperature data	March 31, 2029

Activity 3: Incorporate temperature data into visualization tool and make all data available in GEMS for easy access by researchers and agencies.

Activity Budget: $110,000

Activity Description:
Integrate terrestrial temperature data into an enhanced comprehensive climate visualization tool to enhance research, education, and decision-making. Designed for a 2025 LCCMR project, this innovative tool will incorporate temperature observations to illustrate changes in thermal conditions over time and across landscapes. By merging these datasets with existing water-quality data, users can explore how diverse landscapes affect seasonal dynamics in lakes, freeze-thaw cycles, and long-term warming trends. Ultimately, this tool will be a vital resource for understanding the complex relationships between climate factors and water ecosystems.

All curated temperature datasets will be made accessible through the UMN GEMS Informatics system. This integration will adhere to the GEMS data models and metadata standards, ensuring not only seamless discoverability and interoperability but also the long-term preservation of the datasets. Publishing this data on the GEMS platform promotes data access, enhances cross-disciplinary research, and provides a reliable resource for a comprehensive understanding of the dynamics of Minnesota's ground and subsurface climate. ArcGIS Pro tool(s) and a QGIS plugin will be created to streamline access to and integration of these datasets in desktop GIS. This initiative will empower researchers, policymakers, and the public with valuable insights into climate trends.

Activity Milestones:

Description	Approximate Completion Date
Add surface temperature data to the data visualization tool	December 31, 2029
Add surface and subsurface temperature data to GEMS	January 31, 2030
Create ArcGIS Pro tool(s) and QGIS plugin for easy access to GEMS APIs	February 28, 2030
Refine the data visualization tool based on usability testing	May 31, 2030
Release a fully operational data visualization tool	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Christopher J. Crawford	U.S. Geological Survey Earth Resources Observation and Science (EROS) Center	Serve on the project advisory team as the USGS Landsat Collection 2 surface temperature data product Principal Investigator, Chris will provide insight and advice for using Landsat temperature products.	No
Jeppe Kjaersgaard	Minnesota Department of Agriculture	Participate as an end user on the project advisory team. Jeppe will provide guidance on the necessary products and efficient methods for agency staff to access GEMS Exchange through GIS plugins, enabling them to work with the data produced by this project.	No

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
The primary method for disseminating information will be through the GEMS Exchange, accessible via ArcGIS Pro or QGIS Plugins. This platform will offer access to all Landsat-derived surface data, as well as modeled surface and subsurface data. Users will be able to conduct analyses using other datasets available in the GEMS Exchange and download regional data in raster format, depending on the type of data and stakeholder feedback. Summary products for surface temperature will be included in the climate visualization tool. The tool will be open to federal, state, regional, and local agency staff, as well as to any individuals interested in the data, via an internet browser. It will provide data access through maps and graph-based visualizations for various attributes, allowing users to explore seasonal variations and long-term trends. We will also present our findings in research papers and at conferences focusing on climate, agriculture, and lakes. The ENRTF will be appropriately acknowledged, in accordance with guidelines, including its language and logo, in the climate visualization and data access tool, social media posts, published manuscripts, and presentations.

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?
Terrestrial surface temperature data generated from this project will be added to the GEMS Exchange (https://gems.umn.edu/services/gems-exchange). Maintenance and updates for data processing, as well as the ongoing operation of the temperature data hosted at the University of Minnesota's Supercomputing Institute, will be funded through financial contributions from data users. Additionally, for non-commercial users, the data will be accessible via a water-focused visualization tool currently being developed for a 2025 LCCMR project. This tool will be maintained at U-Spatial and will also rely on financial contributions from data users for its support.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Understanding to Improve Minnesota's Future Lake Water Quality	M.L. 2025, First Special Session, Chp. 1, Art. 2, Sec. 2, Subd. 03cc	$595,000

Project Manager and Organization Qualifications

Project Manager Name: Leif Olmanson

Job Title: Research Scientist

Provide description of the project manager's qualifications to manage the proposed project.
Leif Olmanson will be responsible for overall project coordination and supervision of the study, including working with Porter and GEMS management and staff to develop a satellite image processing methodology to create temperature databases and to develop and apply weather-informed models to predict and forecast subsurface temperatures. He will also work with Wiringa to update the lake-focused climate visualization tool to include terrestrial temperature maps and to create ArcGIS Pro tools and a QGIS plugin to make the data readily accessible for use in geographic information systems (GIS), enabling other research applications. He is currently the project manager for the related LCCMR project M.L. 2025, Chp. 1, Art. 2, Sec. 2, Subd. 03cc 2025-280 and has managed many other remote sensing of water quality projects in Minnesota, Michigan, and Massachusetts, and was a Co-PI on the LCCMR project M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 03b. He has over 30 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 the Minnesota Supercomputing Institute's supercomputers, to better understand the natural environment. He has led and currently leads a team of researchers and computer scientists to build a near-real-time, HABs-focused water-quality and temperature monitoring and forecasting system for Minnesota's >10,000 lakes, using satellite imagery to provide critical water-quality information for citizens and lake managers. He also oversaw the latest modifications of the Minnesota LakeBrowser and ongoing improvements. Runck will coordinate access to MDA and related ground-sensed weather data and will engage with Porter and Olmanson to undertake an inter-model comparison to assess the robustness and precision accuracy of the project outputs.

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 investigators' labs and offices are equipped with the space and facilities required for the proposed work. The Minnesota Supercomputing Institute (MSI) is the University of Minnesota's principal center for computational research. Its main data center is in the basement of Walter Library (room B40) on the U of M Twin Cities campus.

GEMS, a joint CFANS and MSI agri-food informatics initiative at the University of Minnesota, is a highly diverse, international, and interdisciplinary team of professionals. The GEMS Informatics Initiative makes genomics, environmental, management, and socioeconomic data interoperable at varying spatial and temporal scales to generate actionable information and promote innovation partnerships that accelerate and sustain growth in local and global food and agricultural systems.

U-Spatial is nationally recognized as a leading model for how universities can successfully integrate spatial data, visualization, analysis, and spatial thinking. Staff design and develop full stack solutions, which may include database hosting, as well as server and client-side applications such as web-based maps and decision support tools.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
PI - Leif Olmanson		Researcher that Will lead the project			36.6%	1.2		$150,936
Co-PI Kevin Silverstein		GEMS Informatics Operations Manager			36.6%	0.09		$18,688
Co-PI Philip Pardey		GEMS Informatics Co-Director			36.6%	0.03		$10,727
David Porter		Scientific Computing Consultant			36.6%	0.9		$184,491
Peter Wiringa		Web and GIS Developer			36.6%	0.3		$48,188
Bryan Runck		Senior Research Scientist			36.6%	0.15		$29,741
Nathan Carlson		GEMS System Administrator			36.6%	0.2		$33,477
TBD - PostDoc		Researcher			26.1%	1		$88,289
							Sub Total	**$564,537**
Contracts and Services								
University of Minnesota Remote Sensing Laboratory/ MSI/GEMs APIs	Internal services or fees (uncommon)	Access to remote sensing/geographic information systems (GIS) software and computers for model development, and to resources at the Minnesota Supercomputing Institute and GEMs APIs at the University of Minnesota.				-		$12,600
							Sub Total	**$12,600**
Equipment, Tools, and Supplies								
							Sub Total	**-**
Capital Equipment								
							Sub Total	**-**

Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	3 to 4 trips, 2 to 4 people per year	Present results of LCCMR-funded work, outreach, and demonstration of the new capabilities of the GIS plugins to access GEMS Exchange temperature data and the new capabilities of the Lakes-focused climate data visualization tool.					$6,863
							Sub Total	**$6,863**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$584,000**

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				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $584,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 7e7ce958-fc2.pdf

Alternate Text for Visual Component

The surface temperature data will be generated and used with GEMS Exchange APIs to model surface and subsurface conditions. This data will also be integrated into the GEMS Exchange for other research projects and incorporated into a climate data visualization tool....

Supplemental Attachments

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

Title	File
Minnesota Department of Agriculture Letter of Support	269da645-a72.pdf
Christopher J. Crawford USGS EROS Letter of Support	d71c2a9e-f5c.pdf
UMN SPA Letter of Approval	97ad08fc-03e.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?

Yes, I understand the UMN Policy on travel applies.

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

Yes

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

Yes

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF? If so, describe here (1) the source and estimated amounts of any revenue and (2) how you propose to use those revenues:

Yes, Maintaining the pipeline and sustaining future data-generation capabilities will require a reliable funding model. As part of this long-term strategy, we anticipate introducing subscription fees for commercial and other high-utilization users. The resulting revenue will help offset operational and infrastructure expenses, ensuring that we can continue to support scientific research and provide state and local agencies with accessible, cost-effective data resources.

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:

Andrea Little Finance Professional at University of Minnesota-Twin Cities

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