Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-269

Proposal Title: Reducing Urban Heat through Reflective Roofs

Project Manager Information

Name: Tracy Twine

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

Office Telephone: (612) 625-7278

Email: twine@umn.edu

Project Basic Information

Project Summary: We propose to simulate deployment of a reflective film that will cool roofs, reduce energy costs, and mitigate warming.

Funds Requested: $165,000

Proposed Project Completion: 2023-06-30

LCCMR Funding Category: Small Projects (H)
      Secondary Category: Air Quality, Climate Change, and Renewable Energy (E)

Project Location

What is the best scale for describing where your work will take place?
      Region(s): Metro

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

When will the work impact occur?
      In the Future

Narrative

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

The urban heat island (UHI) is a physical phenomenon in which cities are warmer than surrounding rural areas. The UHI results from built surfaces (i.e., roofs, parking lots, road surfaces) absorbing more of the sun's radiation and releasing this as thermal heat. Waste heat from vehicles and the heating/cooling of buildings also contributes to the UHI. The hotter cities are a public health threat in summer whenever a heat wave occurs and the UHI adds to the threat of morbidity and mortality. Minnesota is projected to have more extremely hot days in the future, which will increase this threat. Reducing cooling costs in summer and heating costs in winter is beneficial economically to businesses and environmentally to citizens via reductions in greenhouse gas emissions, as well as overall energy savings. The 3M Corporation has developed a radiative cooling film that both decreases absorbed sun's radiation and enables more heat to be radiated to the sky. The material has been tested over small areas but has yet to be used to cover entire buildings.

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

Our team of scientists at the University of Minnesota proposes to collaborate with a team at the 3M Corporation to test the properties of their material across the Twin Cities Metro Area (TCMA). We choose this domain because it is the largest metropolitan region in the state and because we have recently parameterized a regional weather model for use over this region at fine spatial resolution. However, we expect our results to be applicable to other cities regardless of size. According to the 2010 US Census, Minnesota has 98 cities with populations greater than 10,000. Previous work in our group found that the TCMA has smaller cities with a 'suburban' heat island. Therefore, we propose to use the TCMA as a model test-bed to estimate how much roof area must be covered by the 3M material to reduce the UHI by 1 °C. We expect our results after scaling from a block to the city-scale will help estimate how this procedure may scale in smaller cities.

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 state's natural resources of air and water are threatened directly by pollution from current energy sources, and indirectly from greenhouse gas emissions that lead to global warming. Reducing heating/cooling costs of buildings and mitigating the urban heat island will reduce both of these threats.

Activities and Milestones

Activity 1: Simulating a 1 °C cooling across the Twin Cities

Activity Budget: $82,500

Activity Description:

We propose to run the Weather Research and Forecast model across the downtown areas of Minneapolis and St Paul to determine what fraction cover of the 3M film is required on roofs to lower the summertime daytime maximum temperature by 1 °C. Time is budgeted to reflect data collection with test materials provided by 3M, testing the parameters of the film properties in the model and to perform one control simulation, and three other experiments at various fraction coverages of film.

Activity Milestones:

Description	Completion Date
1. Control run of model complete	2021-10-31
2. Three experimental scenarios complete	2022-06-30

Activity 2: Mitigating urban heat through roof film deployment scenarios

Activity Budget: $82,500

Activity Description:

Once we calculate the fraction coverage of roof film, we will perform scenarios in which we evaluate how this film could realistically be deployed across downtown roofs. We will examine different patterns of continuous and discontinuous film based on maps of building structure. We will also expand our domain to other cities across the state to evaluate the potential to lower their urban heat island.

Activity Milestones:

Description	Completion Date
Analysis of optimal placement of film	2022-12-31
Report on potential to cool other cities	2023-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Lin Zhao	3M Corporation	collaborator	No
Timothy Hebrink	3M Corporation	collaborator	No

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 be funded?

Along with other innovations from Minnesota, 3M has the potential to increase the reputation of Minnesota in creating solutions to the world's greatest challenges. Future climate variability is projected to stress Minnesota's air and water resources. Scientific evaluation of a potential solution to mitigating urban and suburban heat and reducing energy costs will contribute to the state's portfolio of mitigating global warming. This project is not part of a larger project but pursuit of future funding to test the film in other locations and other environmental conditions is likely.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
MITPPC #2: Early Detection, Forecasting and Management of Brown Marmorated Stinkbug (Halymorpha halys)	M.L. 2014, Chp. 312, Sec. 8	-
Understanding Water Scarcity, Threats, and Values to Improve Management	M.L. 2015, Chp. 76, Sec. 2, Subd. 04a	$234,000

Project Manager and Organization Qualifications

Project Manager Name: Tracy Twine

Job Title: Associate Professor

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

Professional Preparation

The Pennsylvania State University   University Park, PA Meteorology   B.S., 1994
University of Wisconsin-Madison   Madison, WI Atmospheric and Oceanic Sciences M.S., 1998
University of Wisconsin-Madison   Madison, WI Atmospheric and Oceanic Sciences Ph.D., 2004

Appointments
Associate Professor, Department of Soil, Water, & Climate, University of Minnesota, 2014-present
Fellow, Institute on the Environment, University of Minnesota, 2017-present
Assistant Professor, Department of Soil, Water, & Climate, University of Minnesota, 2008-2014
Assistant Professor, Department of Atmospheric Sciences, University of Illinois Urbana-Champaign
Faculty Member, Program in Ecology and Evolutionary Biology, University of Illinois Urbana-Champaign, 2004-2007.
Graduate Research & Teaching Assistant, University of Wisconsin-Madison, 1996-2004.
Data Analyst on Boreal Ecosystem-Atmosphere Study (BOREAS), Research and Data Systems Corporation, NASA Goddard Space Flight Center, Greenbelt, MD, 1994-1996.

Dr. Twine's research accomplishments have been in biosphere-atmosphere interactions, primarily the effects of land cover change and climate change on water and energy budgets. Her group has developed high resolution projections of Minnesota's future climate, projected changes to crop production and water use with climate change, quantified the potential effects of the large-scale production of perennial grasses as biomass energy crops on the hydrology of the Upper Midwest, and characterized the Twin Cities urban heat island via citizen science. She has over twenty years' experience with the development, testing, and implementation of dynamic ecosystem modeling. She has used datasets derived from satellite measurements to test these models, and also has experience collecting in situ measurements of biological and micrometeorological variables in grasslands and agroecosystems. She has taught undergraduate and graduate courses including introductory weather and climate, environmental biophysics, and proposal writing for land and atmospheric science. Dr. Twine has advised Mr. Al Gore and Minnesota legislators, and has contributed to Will Steger's Climate Generation, the Bell Museum, and the Science Museum of Minnesota.

Organization: U of MN - Twin Cities

Organization Description:
The mission of the University of Minnesota (UofM) includes Research and Discovery, Teaching and Learning, and Outreach and Public Service. Grand challenges in the College of Food, Agriculture, and Natural Resource Sciences (CFANS) include food security, agricultural productivity, invasive species and biodiversity, pest and disease dynamics, climate change and renewable energy, water resources protection, and educating future leaders in applied science and technology. CFANS includes the Department of Soil, Water, and Climate, whose mission is to advance our understanding of Earth system processes and the interaction among land, atmosphere, and water. Through research, teaching, and extension we seek to improve and protect the quality of soil, air, and water resources in natural and managed ecosystems; enhance agricultural and forest productivity and sustainability; predict and mitigate impacts of environmental and climate change on ecosystems and society; and provide science based knowledge for improved decision making and a better informed citizenry.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Lead Investigator		Supervise Researcher and Graduate Student, oversee all activities. For all personnel, a 2% annual inflation rate has been used to calculate salary. No inflation was calculated into the fringe rate. Funds are requested to support PI Twine for four weeks of summer salary during the grant period (salary total = $11,167; fringe (36.5%) = $4,076) to oversee project activities (supervising research associate and graduate student researcher), and perform data analysis.			36.5%	0.4		$15,242
Researcher		Lead model simulations and data analysis. Funds are requested for a Researcher at 25% effort (salary total = $28,518; fringe (36.5%) = $10,409. The Researcher will conduct research on both Activities including leading the model simulations, analyzing the data, and contributing to peer reviewed publications and project reports.			36.5%	0.5		$38,927
Graduate Student		Perform film tests to model parameters, expand results to other cities. Funds are requested for a graduate student researcher (stipend total = $53,284; tuition = $34,343; fringe (16.1%) = $12,028). The student will assist with both Activities to lead data collection of film tests to help model testing in Activity 1, and to help extrapolate model results to other cities across Minnesota in Activity 2.			16.1%	1		$99,655
							Sub Total	**$153,824**
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								

	Tools and Supplies	data storage charges at MN Supercomputing Institute	Funds are requested to pay for data storage on the Minnesota Supercomputing Institute's (MSI) data drives, necessary to perform model simulations and store data for both Activities. 20TB above the in-kind Tier 1 storage provided by MSI is required for our model storage needs and are charged at $221.52/TB/year for a total of 20TB x $221.52/TB/year x 2 years = $8,861.					$8,861
							Sub Total	$8,861
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
							Sub Total	-
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
	Publication	page charges for journal	costs required to publish peer reviewed research					$2,315
							Sub Total	$2,315
Other Expenses								
							Sub Total	-

							Grand Total	$165,000

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	3M Corporation	Time with collaborators from 3M to incorporate numerical values of thermal and reflective properties in our model simulations and feedback on our results.	Pending	$30,000
In-Kind	Minnesota Supercomputing Institute (MSI)	MSI allows the use of their computing nodes at no charge to run our simulations to investigators with funded projects. Costs to external users are $0.05/SU. We estimate we will need 1,000,000 SUs resulting in $50,000 estimated in kind costs.	Pending	$50,000
			Non State Sub Total	**$80,000**
			Funds Total	**$80,000**

Attachments

Required Attachments
Visual Component
File: 97758014-09c.pdf

Alternate Text for Visual Component
A map of the Twin Cities Metropolitan Area urban heat island averaged over 24 hours and all months (2011-2014) that shows the downtown areas are up to 2 degrees Celsius (4 degrees Fahrenheit) warmer than surrounding rural areas. An example of a Minneapolis neighborhood showing an aerial photo map and a corresponding colored map of land cover classification that is input to the model. The model then maps parameters like reflectance to land cover. A photo of 3M radiative cooling panels. A schematic of how temperature is greater over a city compared with parks, suburban areas, and rural areas with text stating that we propose to alter the reflectance of some portion of the city model grid cells to reduce heat.

Optional Attachments
Support Letter or Other

Title	File
Institutional_Support	35ce37af-172.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?
No

Does your project have patent, royalties, or revenue potential?
No
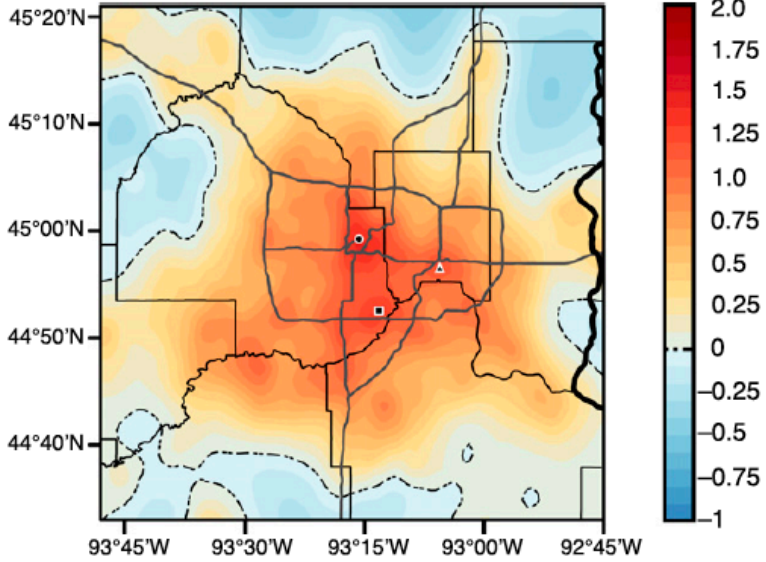
Does your project include research?
Yes

Does the organization have a fiscal agent for this project?
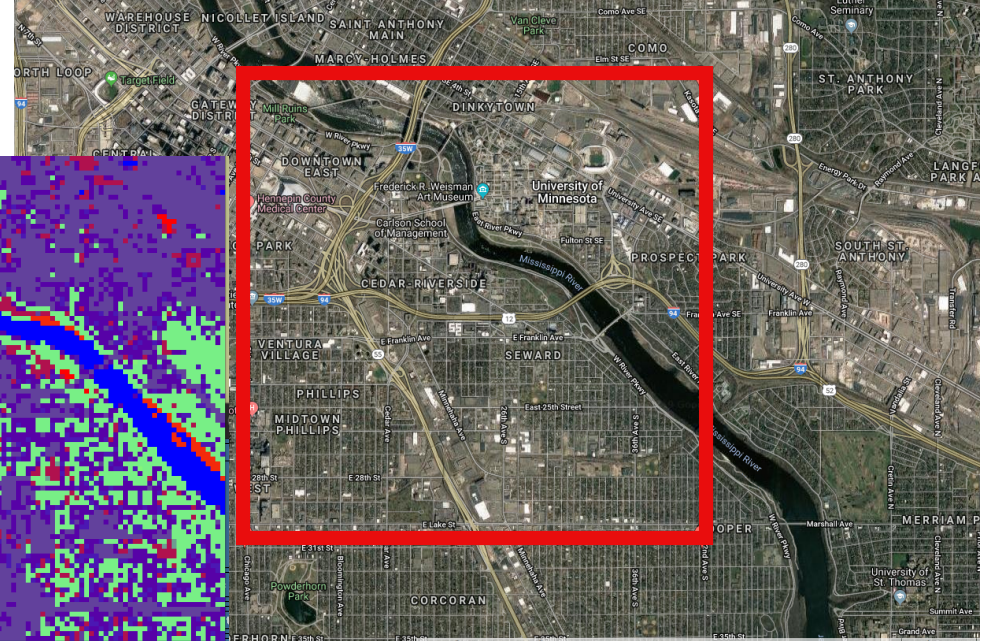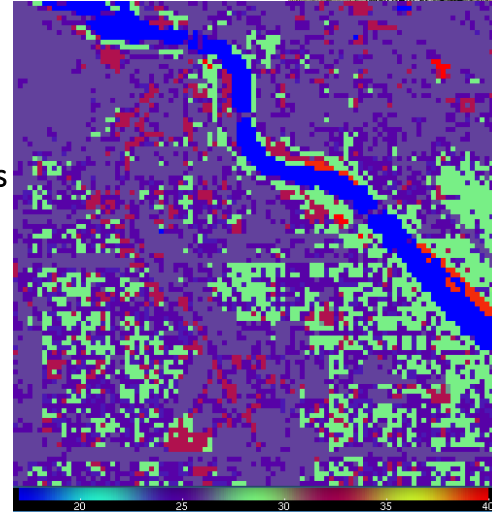Yes, Sponsored Projects Administration

All months
Daily-mean TCMA UHI
Source: Smoliak et al. (2015)

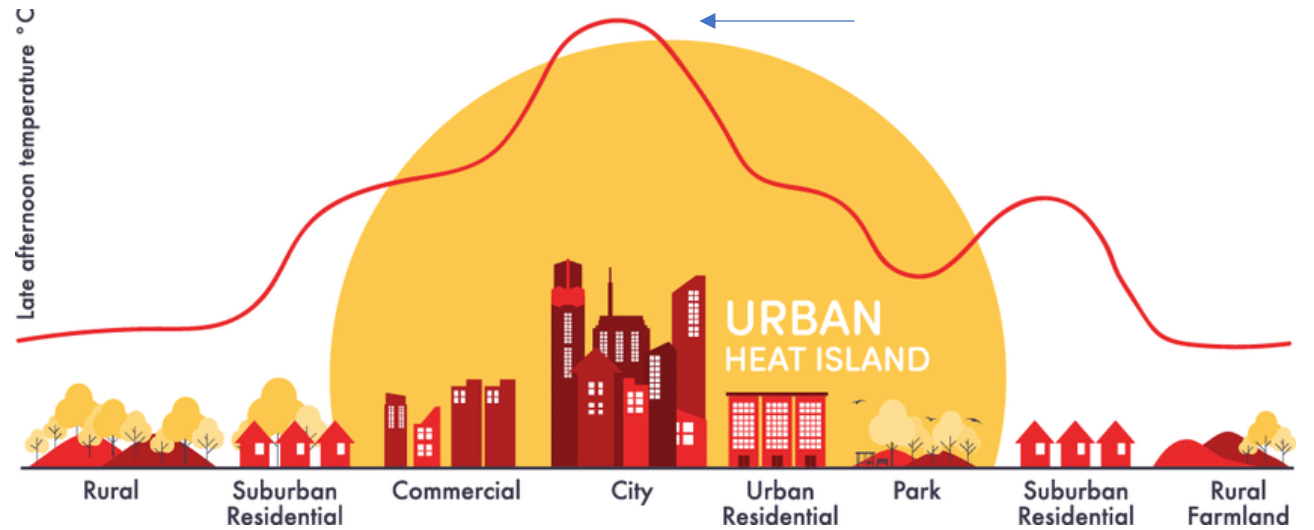Model maps parameters like reflectance to land cover

National Land Cover Database Classification
Purple: Urban
Green: Deciduous Forests
Red: Wetlands
Blue: Water

3M film on radiative cooling panels

Alter reflectance of rooftops to reduce this heat

URBAN HEAT ISLAND

Late afternoon temperature °C

Rural | Suburban Residential | Commercial | City | Urban Residential | Park | Suburban Residential | Rural Farmland

Source: Fuladlu, Riza, and Ilkan (2018)