Environment and Natural Resources Trust Fund
2019 Request for Proposals (RFP)

Project Title: **ENRTF ID: 114-BH**

Minnesota Weather Smart Irrigation System for Water Conservation

Category: H. Proposals seeking $200,000 or less in funding

Sub-Category: B. Water Resources

Total Project Budget: $ 198,766

Proposed Project Time Period for the Funding Requested: June 30, 2022 (3 yrs)

Summary:

The goal is to advance science for developing a next generation of weather smart irrigation systems for urban and agricultural water conservation.

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Sponsoring Organization: U of MN

Title: Assistant Professor

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

The visual demonstrates how satellite and weather forecast data can be used to design a next generation of weather smart irrigation systems.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%
____ If under $200,000, waive presentation?			

I. PROJECT STATEMENT

Sustainability of Minnesota's agricultural expansion and urban development requires continuous efforts in developing new science and technologies for irrigation water conservation. ***A survey by the UMN shows that in the Twin-Cities metro area (TCMA), almost 20% of all treated water is used for summertime outdoor applications—around 50% of which is often wasted due to overwatering by inefficient irrigation.***

The existing smart irrigation systems are inefficient as they cannot "predict" the optimal irrigation scheduling and runtime based on current soil moisture content and "future" precipitation events. For example, a scheduled irrigation may continue to water farmlands and lawns while a storm is arriving in a few hours. The main reason is that there are still gaps in our knowledge that prevent us to take full advantage of ***satellite observations*** *and* ***high-resolution weather forecasts*** for "***predictive***" irrigation scheduling.

The ***goal*** is to advance science for developing a next generation of weather smart irrigation systems for urban and agricultural water conservation. To close the existing knowledge gaps, this research aims to answer the following key questions:

- How can we use satellite data together with high-resolution forecasts of land-weather models to increase efficiency of water conservation in smart irrigation systems?
- How efficient are the existing smart irrigation systems under Minnesota weather and climatic conditions?
- When, where and why can these systems operate with sufficient efficiency and/or fail?

The research leverages current PI's projects with NASA to pursue the following ***objectives***:

- Develop novel computational techniques to integrate data from multiple NASA's satellites, ground weather radars, and land-weather models to produce hyper-resolution weather forecasts that are suitable for predictive irrigation.
- Design a state-of-the-art outdoor irrigation laboratory in the Saint Anthony Falls Lab (SAFL) to develop predictive irrigation tools and examine their efficiency for water conservation in Minnesota climate.
- Mapping the effectiveness of the smart irrigation systems over the entire Minnesota for decision making and technology development.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Producing hyper-resolution forecasts for weather smart irrigation in Minnesota **Budget: $75,000**

The available weather forecasts are not useful to inform smart irrigation systems because of their low spatiotemporal resolutions. For example, precipitation forecasts are often available at every 6 hour over an area of 25×25 km. These days NASA satellites including the Moderate Resolution Imaging Spectroradiometer (MODIS), the Soil Moisture Active Passive (SMAP), the Global Precipitation Measurement (GPM), and the ground weather radars are producing data of evapotranspiration, soil moisture, and precipitation over Minnesota at different spatiotemporal resolutions—from hundreds of meters at every 5 minutes to a few kilometers twice per day.

Outcomes and Products:	**Completion Date**
1. Minnesota Satellite Data Assimilation System (MS-DAS): *This research aims to develop modern computational techniques that integrate the above satellite observations with the outputs of the WRF model to produce hourly weather forecasts with sub-kilometer resolution that are tailored for irrigation applications.*	*July 2020*
2. A web-based server *to make the forecasts accessible for public and private sectors.*	*Oct 2020*

Activity 2: Developing and validating a predictive tool for weather smart irrigation scheduling **Budget: $75,000**

To improve irrigation water conservation, we need to accurately predict the irrigation timing by analyzing the available soil moisture and short-term prediction of precipitation, humidity, and temperature at scales that span a few meters of lawn landscape to kilometers of farmlands. Moreover, we need to thoroughly understand and quantify efficiency of the weather smart irrigation systems in Minnesota's climate.

Outcomes and Products:	Completion Date
1. SAFL Outdoor Irrigation Laboratory: *A modern pilot-scale experimental facility will be design that would enable to continuously monitor and collect data of key environmental variables, irrigation water consumption, and lawn health during the growing seasons in an urban built environment.*	*May 2020*
2. A dataset *will be collected to be used for developing* ***a predictive tool*** *for weather-based urban landscape irrigation.*	*Dec 2021*
3. A prototyped mobile app *will be developed to demonstrate the effectiveness of the predictive irrigation tool and promote further technological developments by private sectors.*	*Feb 2022*

Activity 3: Mapping the effectiveness of smart irrigation systems **Budget: $48,766**

To create new initiatives that promote adoption of weather smart irrigation systems in Minnesota, we need to understand where and when these systems are efficient and cost effective.

Outcomes and Products:	Completion Date
1. Monthly Maps *that demonstrate quantitatively the water conservation effects of the new weather smart irrigation system over the entire Minnesota by compiling information about the climatology of precipitation, soil moisture, evapotranspiration and land use.*	*June 2022*

III. PROJECT STRATEGY

A. Project Team/Partners

Ardeshir Ebtehaj: Assistant Professor at SAFL and Department of Civil Environmental and Geo-Engineering, UMN.

B. Project Impact and Long-Term Strategy

- The outcomes could lead to ***new water conservation technologies and patents*** that take full advantage of satellite data for protection of Minnesota's water resources and sustainability of its economic growth. Any future patents will subject to revenue sharing with the trust fund as outlined in M.S. 116P.10.
- In an effort to help residents to save money and protect natural resources by saving water, the city of Woodbury has created a program in 2018 that purchases smart irrigation controllers in bulk and sells them back to residents for only $20 (retail value: $200). The produced maps about the efficiency of smart irrigation would enable cost effective decision and policy making in this regard across the entire Minnesota's urban areas.
- The currently proposed research mostly focuses on irrigation of lawns in urban landscape. However, the long-term strategy is to extend the research for ***a crop-based weather smart irrigation*** that will have the potential to conserve significant amount water, ***increase the efficiency of crop production and protect Minnesota's natural resources by reducing nutrient reach agricultural runoff.***

C. Timeline Requirements

The project will require 3 years full time efforts of a PhD student and part time efforts by the PI and SAFL staff.

2018 Detailed Project Budget

Project Title: Minnesota Weather Smart Irrigation System for Water Conservation

IV. TOTAL ENRTF REQUEST BUDGET 3 Years: $198,766

BUDGET ITEM	AMOUNT
Personnel:	
Ardeshir Ebtehaj, PI (75% salary, 25% benefits): 23.31% FTE,1.65 months in 3 years. Ardeshir will provide expertize in modeling of meteorological conditions, remote sensing software tool development, and supervision for the GIS web-based design. $22,755	$ 22,755
Staff Engineer and IT support (78% salary, 22% fringe): 20% FTE, 1.8 months. S/He will provide support for redesign of the wind tunnel, equipment purchases, installation, and data collection both in the tunnel and flux tower in the field.	$ 32,758
One graduate student (59% salary, 41% fringe): The graduate student will be in charge of data collection, tool developments, and field validation experiments under the supervision of the project PIs.	$ 136,715
Professional/Technical/Service Contracts:	
Equipment/Tools/Supplies: $6,538 is going to be used for purchasing the following items: a soil heat flux ($565), a net radiometer ($1,233), 5 soil moisture sensors ($930), one heated tipping bucket rain gauge ($638), a humidity sensor ($286), wiring ($2,000), rain and soil msoiture sensors ($25+$137.5).	$ 6,538
Travel: No travel cost is requested.	
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST	$ 198,766

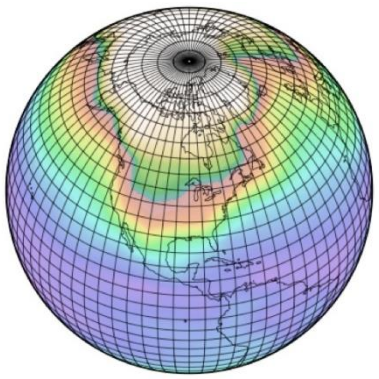
V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

SOURCE OF FUNDS	AMOUNT	Status
In-kind Services To Be Applied To Project During Project Period: Unrecovered UMN overhead (54% MTDC)	$79,391	Secured

Minnesota Weather Smart Irrigation System for Water Conservation

Satellite Observations

Land and Weather Forecasts



An Irrigation Laboratory

rain and soil moisture sensors

Weather Smart Irrigation

WATER CONSERVAITON

Irrigated Agriculture

Lawn Watering

Project Manager Qualifications & Organization Description

Project Manager Qualifications

- Ardeshir Ebtehaj is an Assistant Professor in the Department of Civil, Environmental, and Geo-Engineering (CEGE) at the University of Minnesota and has a joint appointment with the Saint Anthony Falls Laboratory.
- Ardeshir received his **PhD in Civil and Water Resources Engineering** and his **MSc degree in Mathematics** both from the University of Minnesota in 2013.
- He worked for two years as a postdoctoral researcher at the **Georgia Institute of Technology** and he served for one year as an Assistant Professor in Utah State University.
- He is a recipient of **NASA Earth and Space Science Fellowship** in 2013.
- He is currently an **associate editor** of the *Journal of Hydrometeorology* and serves as a member of **precipitation technical committee** of the American Geophysical Union (AGU).
- Ardehsir is a co-principle **investigator** in two major NASA science teams for the **Global Precipitation Measurement (GPM) and Soil Moisture Active Passive (SMAP) Satellites**.
- Ardeshir is the recipient a **NASA's New (early career) Investigator Program (NIP) award** in 2018, which supports outstanding early career scientists who conduct innovative research in earth science using satellite data. The current NASA projects the proposed LCCMR project could create research synergy for benefiting the citizens of Minnesota.

Organization description

The University of Minnesota, Twin Cities is a public research university in Minneapolis and Saint Paul, Minnesota. The University of Minnesota mission is threefold:

- **Research Discovery** – to generate knowledge, understanding and creativity by conducting high-quality research.
- **Teaching and Learning**—to share knowledge and prepare graduate, professional, and undergraduate students to take leadership roles in the state, the nation, and the world.
- **Outreach and Public Service** – to exchange knowledge between university and society by applying scholarly expertise to community problems.