

**Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)**

Project Title:

ENRTF ID: 139-E

Development of an Early-Warning System for Minnesota Droughts

Category: E. Air Quality, Climate Change, and Renewable Energy

Total Project Budget: \$ 265,616

Proposed Project Time Period for the Funding Requested: 3 years, July 2017 - June 2020

Summary:

Complete an early-warning system by creating detailed drought risk assessment maps for Minnesota up to six months ahead using projections of ocean currents to effectively plan for regional water scarcity.

Name: Stefan Liess

Sponsoring Organization: U of MN

Address: 310 Pillsbury Dr SE
Minneapolis MN 55455

Telephone Number: (612) 624-1620

Email liess@umn.edu

Web Address http://www.tc.umn.edu/~liess

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

The image shows a comparison of Minnesota's natural resources and agriculture during normal conditions and during drought conditions. Also shown are schematics of drought risk assessment maps and a diagram that marks important drought periods over Minnesota and their relationship to climate variations over the Pacific Ocean.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____ %



PROJECT TITLE: Development of an Early-Warning System for Minnesota Droughts

I. PROJECT STATEMENT

The proposed project will provide an early-warning system in the form of detailed drought risk assessment maps for the state of Minnesota. Current drought projections are not detailed enough to capture individual states and even less individual counties. Many forecast products are expensive and thus cost-prohibitive for small farmers. Minnesota has frequently suffered from multi-year droughts: besides the 1930's dust bowl that covered 70% of the United States including Minnesota, the drought of 1988/89 ranks as not only the costliest drought in United States history but also the costliest natural disaster in United States history before Hurricane Katrina. Heat waves accompanied this widespread, unusually intense drought and killed around 4,800 to 17,000 people and numerous livestock. The farmers in the state of Minnesota alone saw \$1.2 billion in crop losses. The more recent 2010-2012 drought produced more severe conditions than the 1988/89 drought, but resulted in lower costs for Minnesota because the dry winter of 2012/13 was followed by a warm and wet spring in 2013.

Lack of available water in the atmosphere and the related absence of rainfall are the primary causes for droughts. Available water for rainfall is connected to the natural variations in the atmosphere and the global oceans. Many of these large climate patterns are linked to ocean currents that span thousands of miles and are predictable for many months up to half a year. The goals of this project are to

- 1. compile a list of easily predictable climate patterns that influence drought conditions over Minnesota.**
- 2. create a tool that calculates drought risk based on the presence or absence of these patterns for an early-warning system of droughts over individual counties in Minnesota.**
- 3. provide detailed maps of drought risk for the state of Minnesota with lead times of up to six months.**

The State Climatology Office of the Department of Natural Resources has confirmed that it receives a large amount of requests for detailed drought forecasts, but current drought projections are inadequate to fulfill this urgent need because they are limited to a few patterns including La-Nina pattern over the tropical Pacific. A detailed knowledge of climate patterns and ocean currents in both Atlantic and Pacific Ocean, including the so-called El Niño and La Niña conditions, is necessary to predict droughts over Minnesota throughout the year.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Create a risk assessment tool from statistical analysis of climate patterns **Budget: \$128,955**

Dr. Stefan Liess will collect data from global ocean observations and regional weather archives. A list of reliable climate patterns that preceded droughts since 1880 over all or parts of Minnesota will be compiled from these data. Dr. Liess will perform a detailed statistical analysis of these climate patterns especially over the North Pacific, the North Atlantic, and the adjacent tropical regions to develop a drought risk assessment tool for the state of Minnesota. The statistical calculations will be performed at the Minnesota Supercomputing Institute.

Outcome	Completion Date
1. Dataset of reliable climate patterns over the period of 1880 to present	December 2017
2. Selection of climate patterns sorted by relevance for drought over Minnesota	June 2018
3. Ready-to-use risk assessment tool that predicts detailed drought patterns for every month up to six months ahead	December 2019

Activity 2: Generate and disseminate detailed drought projection maps **Budget: \$108,812**

Dr. Liess will use the drought risk assessment tool developed in Activity 1 to generate detailed maps that show the anticipated drought risk using the drought categories established by the national drought monitor in Nebraska. Initial results from current conditions and tests from past observations will be disseminated to a select group of users to test the tool's usability. After the drought risk assessment tool is adjusted based on



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these reviews, the final risk assessment maps will be available online via a University of Minnesota website. Special emphasis will be put on the usability with smart phones.

Outcome	Completion Date
1. Make risk assessment maps and their data available online	January 2020
2. Improved usability of the resulting risk assessment maps after input from test users	April 2020

Activity 3: Inform and educate water and agricultural managers

Budget: \$27,849

As soon as a general usability of the drought risk assessment tool is achieved, the main efforts of the research team will switch to education and outreach. Dr. Liess will develop education material in the form of online tutorials and short movie clips. Dr. Liess and the graduate student will write peer reviewed publications to provide technical details of the drought risk assessment tool. Three workshops for local water and agricultural managers are planned in the northern and southern parts of Minnesota as well as in the metro area. It is anticipated that about 30 people will attend each workshop. The drought risk assessment tool will be made portable so it can be used and further developed by any interested agency after the project ends.

Outcome	Completion Date
1. Initial set of education material for first usage	January 2020
2. A detailed user manual for the drought risk assessment tool including its portability	May 2020
3. Three workshops for water and agricultural managers	June 2020

III. PROJECT STRATEGY

A. Project Team/Partners

Dr. Stefan Liess will manage and lead the proposed project. He will work with a graduate student who will perform programming tasks for data processing and data analysis. The graduate student will be co-advised by the oceanographer Prof. Katsumi Matsumoto at the Department of Earth Sciences at no additional costs for this project. University of Minnesota staff will aide in bringing the final drought risk assessment product into an easily usable format. This involves generating easily understandable maps and online services. Dr. Liess will develop the main drought risk assessment tool, its website including archives, and adequate education material.

B. Project Impact and Long-Term Strategy

The outcome of this project will result in improved planning capabilities for water management during droughts over Minnesota. Farmers, utility companies, and other water and agricultural managers will be able to adequately prepare for water shortages and the resulting economic and ecological losses during a drought, when usage for irrigation increases and water availability for farming, recreation, and hydropower generation decreases. Existing water supplies can be more efficiently protected with the increased warning time that our drought risk assessment tool will provide. The **Minnesota Department of Agriculture**, the **State Climatology Office** of the **Department of Natural Resources**, and the **University of Minnesota Extensions** program have already expressed their interests in the outcome of the proposed research. After the current project ends, the drought risk assessment tool can be transferred to any interested agency, where it can be further used and improved. It should be noted that the drought risk assessment tool will be designed to include a verification mechanism so that it self-improves after observed drought conditions to incorporate newly gained insights about the importance of individual climate patterns that are relevant for the drought risk assessment.

C. Timeline Requirements

The project will begin on July 1, 2017. It will take 34 months to develop a fully functional drought risk assessment tool that produces easily accessible results using the Minnesota Supercomputing Institute resources. The remaining two months will be spent with education and outreach activities, as well as making the drought risk assessment tool portable so it can be further used after the proposed project ends.

2017 Detailed Project Budget

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IV. TOTAL ENRTF REQUEST BUDGET 3 years

<u>BUDGET ITEM</u>	<u>AMOUNT</u>
Personnel: Dr. Stefan Liess, Project Manager (75% salary, 25% fringe benefits, 3 years, 50% of full-time employment)	\$ 129,381
Personnel: One Graduate Student for programming, data processing, and communicating scientific results (55% salary, 45% fringe benefits (incl. tuition), 3 years, 50% of full-time employment)	\$ 127,235
Equipment/Tools/Supplies: Purchase of storage on existing hard drives at the Minnesota Supercomputing Institute for three years.	\$ 3,000
Additional Budget Items: Publication costs for three scientific articles on newly identified climate patterns, the statistical method, and relationships between large-scale climate patterns and drought over Minnesota.	\$ 6,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND \$ REQUEST	\$ 265,616

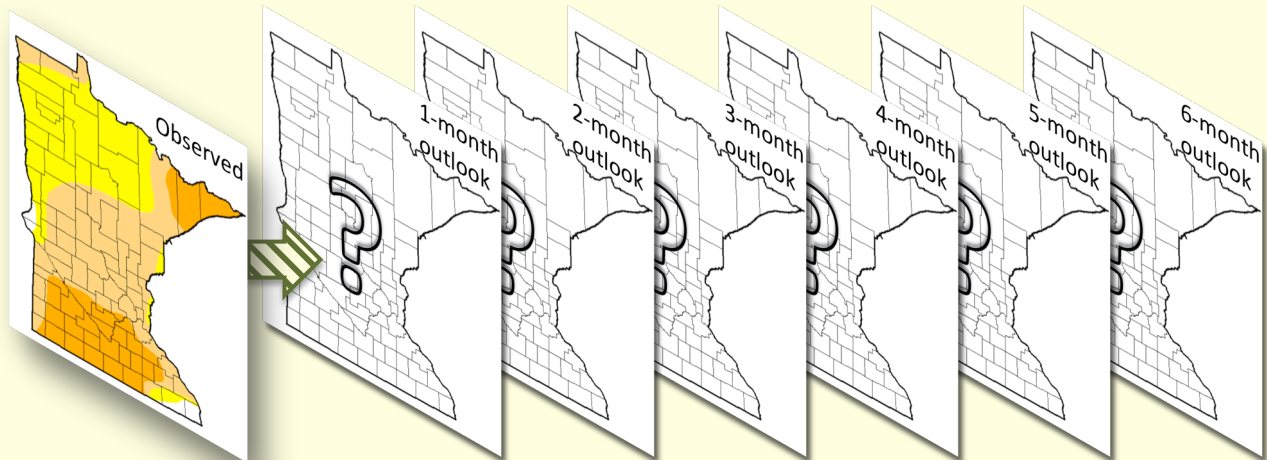
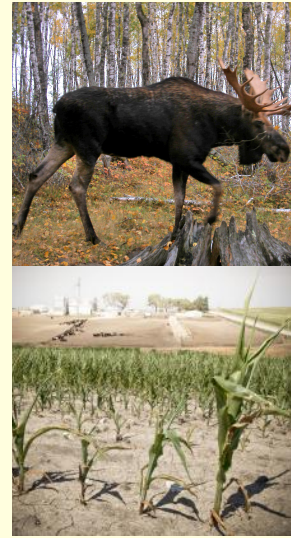
V. OTHER FUNDS

<u>SOURCE OF FUNDS</u>	<u>AMOUNT</u>	<u>Status</u>
Other Non-State \$ To Be Applied To Project During Project Period: N/A	\$ -	-
Other State \$ To Be Applied To Project During Project Period: N/A	\$ -	-
In-kind Services To Be Applied To Project During Project Period: Dr. Liess receives access to the Minnesota Supercomputing Institute and its High - Performance-Computing facilities at a rate of \$10,500 per year.	\$ 31,500	<i>Secured</i>
Funding History: N/A, this is a new research initiative.	\$ -	
Remaining \$ From Current ENRTF Appropriation: N/A	\$ -	-

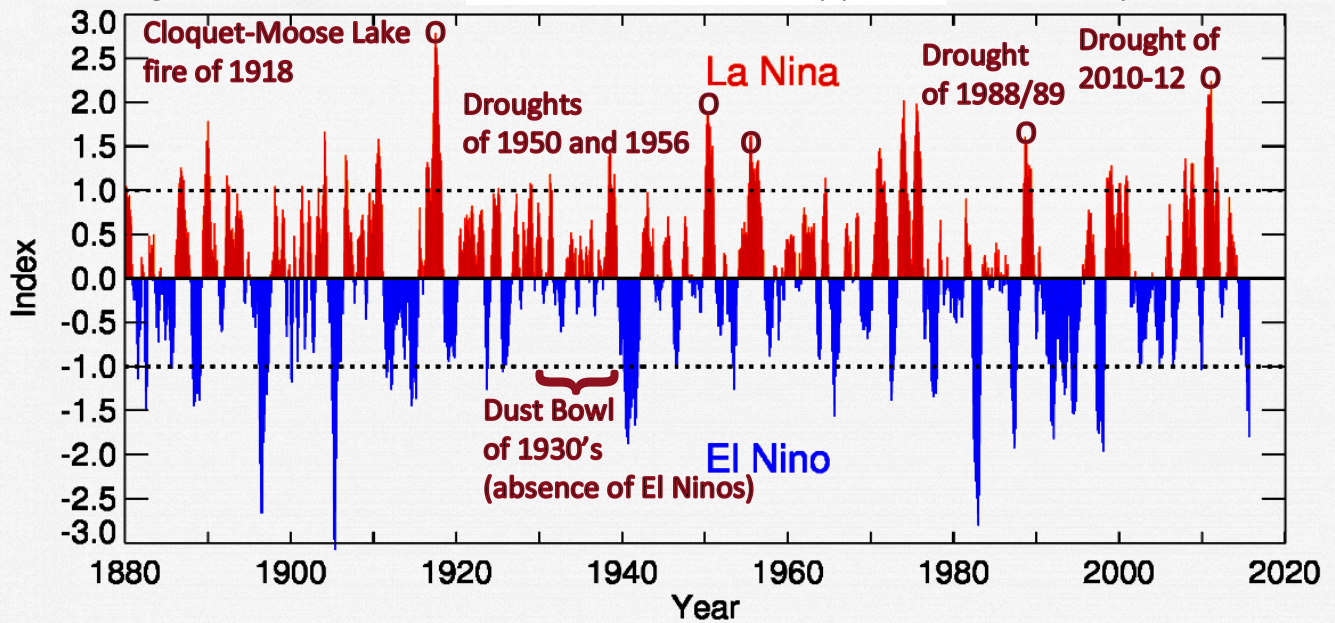
Development of an Early-Warning System for Minnesota Droughts helps to minimize economic and environmental losses:



Minnesota needs an early-warning system to effectively plan for drought periods.



Drought conditions over Minnesota are influenced by predictable climate patterns:



Project Manager Qualifications & Organization Description

PROJECT TITLE: Development of an Early-Warning System for Minnesota Droughts

Dr. Stefan Liess

Gibson Research Associate of Hydrogeology
Department of Earth Sciences
University of Minnesota – Twin Cities
Phone: (612) 624-1620
Email: liess@umn.edu

Dr. Liess received his Ph.D. in atmospheric science with subsidiary subject oceanography from the University of Hamburg, Germany in collaboration with the Max Planck Institute for Meteorology in 2002. For his research, he received a 3-year stipend from the Max Planck Society. His research interests encompass observational data analysis of the atmosphere and oceans, and impacts on the land surface. As a post doctoral fellow at the Institute for Terrestrial and Planetary Atmospheres at Stony Brook University in New York, he secured funding from the National Oceanic and Atmospheric Administration (NOAA) to perform reliable tropical rainfall forecasts for more than 30 days related to global and regional atmosphere and ocean phenomena, and their interactions with the land surface. He also received funding from the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) to study the impacts of the upper atmosphere on cloudiness and to provide an online portal for scientific data. From 2004 to 2009, he was the responsible scientist and system administrator for the SPARC (Stratosphere-troposphere Processes And their Role in Climate) Data Center at <http://www.sparc-climate.org/data-center>. SPARC is one of four core projects of the World Climate Research Programme (WCRP). Dr. Liess' teaching experience in undergraduate and graduate level courses in atmospheric physics and environmental studies includes topics such as synoptic meteorology, climatology, and environmental studies.

Dr. Liess joined the University of Minnesota in 2008. Initially, he worked with Prof. Peter Snyder in the Department of Soil, Water, and Climate on impact assessments of vegetation changes on climate over the Arctic region. He collaborated with the Department of Computer Science to perform statistical analyses on large datasets for the detection and explanation of global climate phenomena. In October 2015, Dr. Liess moved to the Department of Earth Sciences as a hydrogeologist to fulfill the need for an integrated research approach to study the water cycle.

Department of Earth Sciences, University of Minnesota - Twin Cities

The Department of Earth Sciences is part of the Newton Horace Winchell School of Earth Sciences and belongs to the College of Science and Engineering at the University of Minnesota. It includes about 25 full faculty members and about 50 researchers. It awards bachelors, masters, and doctorate level degrees in Earth Sciences and various sub-disciplines, including hydrogeology. A number of on-going research projects in the department focus on Minnesota water resources. Large-scale computer calculations are performed at the Minnesota Super Computing Institute (MSI). MSI provides state-of-the-art computational resources and experienced technical user support. MSI maintains two high-performance supercomputers with a total of 27,496 processors, a large variety of software, and 2.8 PB (petabytes) of high-performance data storage space.