# WATER CURRENT

**NEBRASKA WATER CENTER**
PART OF THE DAUGHERTY WATER FOR FOOD GLOBAL INSTITUTE AT THE UNIVERSITY OF NEBRASKA

**SUMMER 2023**

## Core Research, Events, and News from the Nebraska Water Center


Niobrara State Park, Nebraska

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**And More!**

# From the Director

## Chittaranjan Ray, Ph.D., P.E.

**Director, Nebraska Water Center (NWC)**

Dear Reader,

2023 seems to be going by quickly as we have already reached the middle of the summer. We have been busy this summer and I am excited to share an update on the research and events the Nebraska Water Center has been working on over the past few months.

A primary summer highlight was our 49th Annual Water and Natural Resources Tour. Along with Central Nebraska Public Power and Irrigation District, we hosted several colleagues and partners in Norfolk, Nebraska, and Yankton, South Dakota, in June. You can read more about the Tour on Page 4.

We are also pleased to share updates on research from various NWC teams. Our researchers have been making strides in PFAS and other emerging contaminants (Page 8), vadose zone research (Page 9), and new models for soil carbon and carbon dioxide respiration (Page 10). These projects feature both new and existing partnerships, recent funding opportunities, and newly published journal articles. You can read more about our research throughout this newsletter.

Each year, the Nebraska Water Center provides grant funding for research through the U.S. Geologic Survey's 104b program. 104b awards are geared towards early-career faculty who are conducting research in Nebraska that has unique applications both within and outside of the state. In 2023, a total of $95,460.74 was awarded. You can read more about the projects we are funding this year on Page 7.

As we wrap up summer and look to fall, we hope you will join us at our annual conference. On October 3 and 4, we will meet in Omaha to learn about Nebraska's urban water. You can find more details about the conference on the following page. I look forward to engaging with many of you at the fall conference, and at other events this summer and fall.

Chittaranjan Ray

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# Nebraska Water Conference

*October 3 and 4, 2023*

*Downtown DoubleTree Hotel, Omaha, NE*

Registration is now open for the 2023 Nebraska Water Conference in Omaha, Nebraska, on October 3 and 4. This year's conference theme is "Managing water resources in urban Nebraska: *Learning from the past to prepare for the future*." The conference has been hosted in various cities across the state for the last several years, and we are excited to bring a new focus this year.

As Nebraska's metro areas continue to grow, unique management strategies will be necessary to provide enough resources to support future populations. This interactive conference will discuss solutions to the changing use of Nebraska's natural resources with the feedback of interdisciplinary experts on how to approach the future of water management in eastern Nebraska.

The conference will feature keynote sessions about managing water resources in urban Nebraska and the future of water management in Nebraska's metro areas. Tuesday will offer breakout sessions about Missouri River management, water quality, urban design, management practices, and new tools for water management. The day will also include student research poster sessions where students can compete for a cash prize.

Tuesday evening will include a networking reception, with full details to be announced in the upcoming weeks.

On day two of the Nebraska Water Conference, attendees will have the opportunity to go on one of four tours hosted by our partner organizations.

The tours include:

- Platte West water treatment plant, hosted by MUD
- Research site tour, hosted by UNO
- Urban water projects, hosted by JEO Consulting
- Flood management projects, hosted by Papio-Missouri River NRD

Registration is open until September 15.

- Early bird (until August 15): $350
- Regular registration (August 16 to August 31): $450
- Late registration (September 1 to September 15): $500

Registration includes all sessions and meals, as well as the Tuesday evening reception and the tours on Wednesday.

To register for the 2023 Nebraska Water Conference, visit **go.unl.edu/waterconference**.

# 2023 Water and Natural Resources Tour

**By Emma Dostal, Communications Intern**

The Nebraska Water Center with the Central Nebraska Public Power and Irrigation District hosted the 49th Annual Water and Natural Resources Tour in June, which featured discussions about water issues and projects in northeastern Nebraska. The Water and Natural Resources Tour brought together industry experts to continue fostering a deeper understanding of water and its beneficial uses.

The Water and Natural Resources Tour was first held in 1975. The tours are designed to enhance understanding and appreciation for water management in Nebraska and beyond, providing an educational experience for anyone interested in natural resource management.

"The 2023 Water Tour provided the perfect mix of education, recreation, and networking," said Ann Briggs, Public Relations and Engagement Coordinator for the Nebraska Water Center. "The lessons learned about water management in northeast Nebraska were more powerful because we were able to experience the landscape and meet the people who work and live in this part of the state."

The Tour included stops about riverfront development, nitrate and sedimentation issues, wildlife and fisheries efforts, demonstration farms, water-powered manufacturing processes, and more.

A Tour favorite was Lewis and Clark Lake. One attendee said, "the lake was very inspiring in regard to water management and sedimentation problems that they have as a water facility."

The tour at Lewis and Clark Lake was sponsored by Nebraska Game and Parks. Attendees took a boat tour around the lake while guides discussed current issues the lake faces as well as the history of building the lake. Lewis and Clark Lake has faced several challenges since Spencer Dam broke in the 2019 flood. Since then, there has been an increase of sedimentation flowing from the Niobrara River to the Missouri River. Nebraska Game and Parks is also combating invasive species while trying to increase wildlife populations in the lake.

Norfolk Riverfront Development Presentation

Overlook of Gavins Point Dam

Group photo on boats at Lewis and Clark Lake

Attendees ride boats on Lewis and Clark Lake

Missouri Sedimentation Action Coalition presentation at Niobrara State Park

Group photo at Niobrara State Park


Inside Gavins Point Dam

Soil demonstration from Bow Creek Watershed Project at Steffen Farm

Attendees also enjoyed the Bazile demonstration farm and presentation. The Bazile Groundwater Management Area works with Nebraska Extension and four local Natural Resources Districts (NRDs) to test how different farming and fertilization techniques affect the nitrate concentration in the groundwater. This partnership began in 2013 and continues as an educational program for stabilizing nitrate levels.

The stops that highlighted the work of extension were the best parts of the tour, and Bazile's knowledge and passion was very helpful, an attendee said.

All the tour stops included necessary elements in showing the importance of water in production, recreation, power, manufacturing, and insuring Nebraska wildlife will have healthy habitats in the future.

The Tour would not have been possible without our sponsors. Thank you to the UNL Institute of Agriculture and Natural Resources, the Daugherty Water for Food Global Institute, HDR, JEO Consulting Group, Reinke Irrigation, Lower Elkhorn NRD, and Upper Elkhorn NRD for sponsoring the 2023 Water and Natural Resources Tour.

Hosting the Water and Natural Resources Tour each year is necessary to understand important water issues and projects happening throughout the state and encourage attendees to foster a deeper understanding of water and its many beneficial uses while training future water researchers.

# Karina Schoengold Named Associate Director

**By Ann Briggs, Public Relations and Engagement Coordinator**

Karina Schoengold

The Nebraska Water Center recently named Karina Schoengold as the new Associate Director. In this role, Dr. Schoengold will assist the director in the administration of the Center as well as take a leadership role in coordinating multi-disciplinary grant proposals to federal/state agencies and private/non-profit donors. As Associate Director, Dr. Schoengold will work directly with faculty and staff to form teams of researchers with complimentary expertise in developing large research and extension proposals to address some of the critical water problems of the state.

"I started working in water resource economics as a graduate student in California," Schoengold said, "and I find the interdisciplinary nature of water research to be fascinating. As an economist, most of my work is related to incentives, policy design, and improving water management. I have been affiliated with the Nebraska Water Center since I started working at UNL, and have regularly participated in NWC activities and projects. I enjoy collaborating with researchers and stakeholders from a variety of fields, and the NWC position is an excellent opportunity to enhance existing collaborations and build new ones. I enjoy developing partnerships to address important issues, and the NWC is a place where I can be effective in doing so."

Dr. Schoengold will begin her time as Associate Director by focusing on building connections.

"The University of Nebraska already has dozens of accomplished researchers and talented educators in many disciplines that work on topics that are relevant to water management," Schoengold said. "However, many of these individuals may not know about the range of other work being done in Nebraska, and where there may be important connections. One of my first priorities is to learn more about the broad range of work on water at the University of Nebraska so that I can use that knowledge to help create teams that can address relevant water issues. In my experience, teams are most successful when they develop a long-term collaboration, and I will help create those collaborations. Decisions about water management and water policy typically have a human aspect, and one of my priorities is to include economics and other social sciences within teams to increase the impact that scientific research has on behavior, policy, and outcomes. In addition, for research to be relevant, it is important to include stakeholders such as the Natural Resources Districts and other water programs within the state in the process of defining priorities for water research."

The Associate Director position is a 20% appointment, and Dr. Schoengold will serve the other 80% of her appointment by continuing her role as a professor of Agricultural Economics.

# Nebraska Water Center Welcomes Summer Interns

**By Emma Dostal, Communications Intern**

Emma Dostal

Emma Dostal is the Communications Intern with the Nebraska Water Center. This summer and fall semester, Dostal will assist in various projects including creating print designs, promotion materials, social media posts, and working in event management by helping the Center prepare for the 2023 Nebraska Water Conference.

Dostal attended the 49th Annual Water Tour where she helped the NWC continue its mission of fostering a deeper understanding of water and its many beneficial uses.

"After attending the Water Tour and seeing the crucial work that researchers are doing to keep Nebraska water clean for public use, I am even more excited to help share the Nebraska Water Center's mission and work with crucial audiences," Dostal said.

She is a senior at the University of Nebraska-Lincoln majoring in advertising, public relations, and global studies with minors in French and political science.

Dostal most recently served as the communications intern for the U.S. Grains Council where she created graphics, organized two social media campaigns, and wrote press releases while assisting with preparations for a global conference. Other previous roles include interning for the Central Diplomat in Residence with the U.S. Department of State where she focused on public relations projects and the Event Management and Marketing internship with Geronimo Hospitality Group focusing on wedding management.

**Sarthak Das**

Sarthak Das is the Data Management Intern for the summer. Das will work with the Center's data sets to verify they are accurate and repurpose the information for easy future use.

"I am excited for this opportunity to grow my knowledge of computer programming and to understand the logistics of working for an organization like the Nebraska Water Center," Das said.

Das is an incoming freshman at the University of Texas-Dallas where he will be majoring in computer science.

Welcome to the Nebraska Water Center Emma and Sarthak!

Sarthak Das

# Nebraska Water Center Provides 104b Funding for 5 Nebraska-based Research Projects

**By Ann Briggs, Public Relations and Engagement Coordinator**

Each year, the Nebraska Water Center provides grant funding for research through the U.S. Geologic Survey's 104b program. 104b awards are geared towards early-career faculty who are conducting research in Nebraska that has unique applications both within and outside of the state. In 2023, a total of $95,460.74 was awarded.

Awards were granted to the following five projects:

**Fire and Lakes, by Jessica Corman and Daniel Gschwentner ($29,841)**

We propose to study how grassland fires affect lake ecosystems by 1) determining the impacts of wildfires on lake productivity, 2) assessing food web impacts of wildfire ash inputs to lakes, and 3) evaluating the proximity of historical and contemporary wildfires in grasslands to lakes. We will conduct manipulative experiments to determine the effect of fire on lake ecosystem processes and food webs, and analyze spatial data sets on fire occurrence to determine fire proximity to lakes in grasslands. Our study will generate novel insights into how fires shape the flow of resources and energy in grassland lake ecosystems and will aid management of aquatic ecosystems under changing fire regimes. Further, this work will provide necessary insights and data to develop future proposals to the US Geological Survey, the US Department of Agriculture, and/or the National Science Foundation.

**Synergistic effect of biochar and biosolids to limit nitrate leaching beneath cropland, by Arindam Malakar and Michael Kaiser ($10,000)**

This project aims to develop sustainable agroecosystem services and mitigate nitrogen loss beneath the root zone by applying biochar and/or biosolids to agricultural soil in an urban-rural transition zone using no-till and cover crop practices. The study focuses on the synergistic effects of biochar and biosolids in enhancing nitrogen use efficiency and reducing nitrate loss, thereby safeguarding groundwater quality. The project also aims to reduce municipalities' carbon footprint, enhance production, and lower fertilizer usage. By setting up a long-term field experiment in the urban-agricultural landscape of Lincoln, Nebraska, the project intends to provide effective soil management strategies that can improve soil health, water efficiency, and soil organic carbon storage without compromising agricultural yield. The study's relevance lies in addressing the challenges posed by population growth, intensive agricultural practices, soil degradation, and water quality depletion.

**Managing irrigated cropping systems for drought resilience and vadose zone nitrate control: field evaluations and modeling, by Abia Katimbo, Sahila Beegum, Daran Rudnick, Arindam Malakar, Hope Njuki Nakabuye, and Nicolas Cafaro La Menza ($29,962)**

Poor management of irrigation and nitrogen fertilizers has led to high nitrate concentrations in domestic wells in Nebraska, posing a severe health risk to the citizens.Improved management practices need to replace current producer's practices to ensure better use of resources, build resilience to severe drought, and protect the environment. Studies have shown that using cover crops can enhance efficient use of irrigation and nitrogen through water conservation and reduced nitrogen requirements by natural nitrogen recycling. However, a knowledge gap still exists regarding the benefits of combining cover crops with best management practices in irrigated cropping systems (continuous or rotational corn and soybeans) in a semi-arid region such as Western Nebraska, which warrants investigation. This will be achieved by setting up experiments at research fields focusing on growth-stage based management strategies as well as on two producer fields where common practices will be compared to other scenarios of management practices using the 2DSOIL-crop modeling. This grant will not only provide training opportunities to graduate and undergraduate students but will also facilitate data collection to gather enough preliminary data to apply for extramural grants, such as USGS 104g and USDA-NIFA.

**Growing groundwater science, by Chris Huber, Daniel Snow, and Dick Ehrman ($14,358.74)**

Domestic well water is vulnerable to contamination from anthropogenic and geogenic contaminants such as nitrate and arsenic. Few are regularly tested, even fewer are tested for the presence of arsenic species. A growing youth-led citizen and community science program promises to elevate the issue of domestic well water quality and provide additional motivation for regular well water quality testing in Nebraska. Undergraduate students at a 4-year southeast Nebraska university will be trained in well water testing, and work with a local high school to properly sample and test domestic wells from the surrounding area. Students will learn how hydrogeology and land use all affect domestic well water quality, and communicate results to local stakeholders. Highschool students will compare their measurements to the conventional laboratory measurements, while undergraduate students will compare arsenic test kit results to advanced instrumental methods and evaluate hazards associated with consumption of untreated well water. This project will build on USGS research aimed at understanding temporal and regional changes in US drinking water supplies.

**Metal oxide precipitate on irrigation center pivots as a non-invasive screening tool for redox sensitive trace metals in groundwater, by Jeffrey Westrop ($11,299)**

Regular groundwater sampling and analysis is key for identifying areas at risk of contamination. However, sampling and analysis is a time-consuming process, so the ability to screen rapidly and efficiently for potential groundwater quality issues would be advantageous. A recent study demonstrated that the presence of "rust", metal oxide coatings formed when iron or other metal rich groundwater sprays onto the surface of the pivot, could be used to identify areas with low groundwater nitrate, suggesting the potential for using the presence or absence of "rust" to quickly assess groundwater quality over larger areas with less sampling of groundwater. The proposed research will determine if the presence or absence of pivot rust can be used to screen for other groundwater contaminants, particularly trace metals. Groundwater will be sampled from agricultural wells associated with center pivots at several sites. The concentrations of trace metals between sites with and without pivot rust will be compared. The results of this study may be used to leverage observations of pivot rust as a rapid screening tool for groundwater chemistry that may be applied to agricultural systems in Nebraska and globally.

# PFAS Research Brings Student Training and Industry Partnerships

**By Ann Briggs, Public Relations and Engagement Coordinator**

The Water Sciences Laboratory is a leading facility for many advanced environmental testing methods and is always developing new methods to address new contaminants of concern. Recently, a group of contaminants known as "PFAS" have become a growing concern in Nebraska and across the country.

**What are PFAS?**

PFAS, or per- and polyfluoroalkyl substances, originate from fluorinated compounds such as Teflon™ and were first developed in the 1930's for industrial and consumer goods. Because PFAS are resistant to heat, water, oil, and grease, they are useful in household products, paint, non-stick pans, fabrics, food packaging, fire-fighting foam, and more. PFAS are effective in these uses because their chemical bonds are strong and hard to break down.

PFAS are considered an emerging contaminant as more is learned about them. While they're effective in many uses, there are also health concerns related to long-term exposure. Associated health risks include altered immune systems, elevated cholesterol, hormone disruption, and kidney and testicular cancer.

PFAS have been detected in crops, ground and surface water, aquatic wildlife, and even human tissues. Because PFAS are found in many materials people use daily, they are difficult to regulate as a contaminant.

In March, the EPA proposed a new rule to limit 6 PFAS in drinking water. **https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas**

While drinking water isn't the only concern for PFAS exposure, it is a primary concern due to potential for ingestion of PFAS.

**New Funding from NDEE**

This summer, the University of Nebraska received funding from the Nebraska Department of Environment and Energy (NDEE) to identify PFAS in wastewater treatment plants in Nebraska. The project, led by Dr. Shannon Bartelt-Hunt, chair of the Department of Civil and Environmental Engineering, and Dr. Daniel Snow, director of the Water Sciences Laboratory, will include intensive sampling at wastewater treatment plants from across Nebraska to see what types and concentration of PFAS are present in treated and untreated wastewater and biosolids. Treatment plants that serve under 10,000 residents will be the focus.

Project lead, Shannon Bartelt-Hunt, said "This new project gives us a wonderful opportunity to determine a baseline for PFAS in Nebraska wastewater which will help inform the next steps for controlling PFAS in Nebraska".

Once there is a survey of PFAS levels and distribution from across the state, work can be done to address concerns and make plans for future management and mitigation.

This funding provides a continuation of a PFAS research project previously funded by the Nebraska Water Center's 104b grant program. The initial research team included Daniel Snow, Tiffany Messer, Shannon Bartelt-Hunt, and supported graduate student Justin Caniglia and undergraduate intern Patrick Niyitugize. The purpose of the first study was to develop methodologies for testing PFAS and to document occurrence in wastewater and biosolids applied to cropland.

"PFAS testing is hard because it's in everything", Water Sciences Lab Director Dan Snow shared. "Lab equipment, clothing, sample vials, and more. So, samples and equipment are easily contaminated".

Another challenge in PFAS testing is the detection limit. The relevant levels of PFAS and other emerging contaminants is in the parts per trillion and even part per quadrillion. The U.S. Enviromental Protection Agency currently has a recommended limit of 4 parts per trillion of PFAS in drinking water in order to avoid the health-related risks.

Highly sensitive equipment that is only used for PFAS testing is required. Through funding provided by multiple sources, including the Nebraska Research Initiative, Institute of Agriculture and Natural Resources, and the Daugherty Water for Food Global Institute, the Water Sciences Lab was able to purchase and install specialized equipment that is only used for PFAS testing. Having equipment used only for PFAS testing is important to avoid cross-contamination and provide highly sensitive and accurate test results.

Undergraduate intern Patrick Niyitugize retrieves a passive sampler used in the 104b project

**Student Training**

One of the primary outcomes of the Nebraska Water Center and the Water Sciences Lab is to provide opportunities for student training and education. The Nebraska Water Center 104b project funded the initial PFAS research led by then-graduate student Justin Caniglia in the School of Natural Resources. This new project will support a new Civil and Environmental Engineering graduate student, Maddee Rauhauser.

This project isn't Maddee's first experience working at the Water Sciences Laboratory.

"I started working at WSL as an undergraduate intern in 2021, then took a gap year and worked full time as a lab technician which is when I really started working on PFAS," Maddee shared. "The graduate student previous to me, Justin, had written up our PFAS methods and I got the job of running all the PFAS samples."

Maddee's graduate research assistantship will make her an instrumental part of the project funded by NDEE. She is responsible for building on the lab's existing testing methodologies to create methods to test for PFAS in solids as well as water.

"My graduate project has become adapting a new PFAS method for both water and solids," Maddee said. "The EPA has released a new draft method and so it's my job to get that up and running in our lab. I'll be going out to wastewater treatment plants that serve less than 10,000 people to trace and monitor how much PFAS comes in, how much PFAS goes out, and if it accumulates in biosolids."

**Industry Partnerships**

As PFAS are becoming a topic of interest to the Environmental Protection Agency, the work is growing beyond research institutions. Through the NDEE funding, the Department of Civil and Environmental Engineering and the Water Sciences Laboratory will partner with Teledyne ISCO to compare different sampling methodologies.

Teledyne ISCO is an environmental sampling company based in Lincoln which has patented composite, robotic, and automatic samples for surface water. Their sampling methodologies have the potential to collect more data because the samplers can be programmed to collect samples at set time intervals without requiring a researcher to physically go and collect the samples. As part of the current research, the quality of samples collected by the Water Sciences Laboratory will be compared to samples collected by Teledyne ISCO equipment, allowing for the potential to scale up future PFAS research.

PFAS are a growing concern across the nation. As we continue to learn more about this emerging contaminant, having a baseline of information will make future decision making more effective. This research project and the work the Water Sciences Laboratory is doing to create improved testing and sampling methodologies can improve Nebraska's water quality and our ability to respond to future PFAS challenges.

## Research Team Continues to Expand Vadose Zone Work

**New publication on legacy nitrogen, arsenic, and uranium in the vadose zone**

A new study from a Nebraska Water Center research team discusses the relationship between legacy nitrogen and inputs on arsenic and uranium in the vadose zone. Titled "*Interplay of legacy irrigation and nitrogen fertilizer inputs to spatial variability of arsenic and uranium within the deep vadose zone,*" this article was published in Science of the Total Environment and continues the work the research team has been conducting on the vadose zone in Nebraska.

Read the full study at **https://www.sciencedirect.com/science/article/pii/S0048969723039220?dgcid=author.**

**USDA NIFA-funded vadose zone study targets water quality concerns due to intensive agriculture in Nebraska**

Nitrate pollution in the groundwater resources of Nebraska is a looming challenge. The research team is led by Dr. Arindam Malakar, a research assistant professor at Nebraska Water Center and School of Natural Resources. The team includes experts in the field – Dr. Daniel Snow, a research professor in the School of Natural Resources and Director of the Water Science Laboratory; Dr. Erin Haacker, an assistant professor in the Department of Earth and Atmospheric Science; Dr. Chittaranjan Ray, director of the Nebraska Water Center; USDA-ARS scientists Dr. Dan Miller and Dr. Tim Green; and graduate student Yvon Ukwishaka. They are conducting a statewide study, funded through the USDA Agriculture and Food Research Initiative (AFRI) program, to investigate nitrogen biogeochemical transformation in the vadose zone—the portion of Earth above groundwater. To understand the anthropogenic effect on various nitrate transformation processes within the vadose zone, the researchers collected soil cores from a pristine native prairie area at Homestead National Historical Park. These soil cores will be used to create columns representative of the vadose zone and divided into three groups simulating different irrigation regimes: Pivot, Gravity irrigation, and Dryland. Columns will be supplied with N-15 labeled fertilizers, and corn will be grown. The chosen prairie area serves as an essential baseline, allowing researchers to analyze changes in vadose zone biogeochemistry when prairies are converted to croplands. The study particularly aims to shed light on the complex interplay of factors influencing nitrogen transformation in the vadose zone, including the impact of fertilizer type and various irrigation practices.

From right to left: Dr. Arindam Malakar (NWC researcher and SNR Research Assistant Professor), Matt Girard (CSD intern), Yvon Ukwishaka (SNR graduate Student), Sean Kruse (Drilling technician), Jesse Bolli (Homestead National Historical Park Resources Management Specialist) and Matt Marxsen (CSD Drilling manager) at Homestead National Historical Park

From left to right: Matt Girard (CSD intern), Yvon Ukwishaka (SNR graduate Student) and Sean Kruse (Drilling technician) at Homestead National Historical Park

# New Publication Outlines the Development of the Soil Carbon and Carbon Dioxide Respiration Model

**By Ann Briggs, Public Relations and Engagement Coordinator, and Sahila Beegum, Post-doctoral Research Associate**

A Nebraska Water Center research team is making advancements in soil carbon (C) and carbon dioxide ($CO_2$) respiration modeling. Post-doctoral research associates Sahila Beegum and Wenguang Sun worked in conjunction with the USDA's Agricultural Research Service (USDA-ARS) in Maryland to publish the most recent update, titled "*Incorporation of carbon dioxide production and transport module into a Soil-Plant-Atmosphere Continuum model*" (published online on July 12, in Geoderma, an Elsevier Publication).

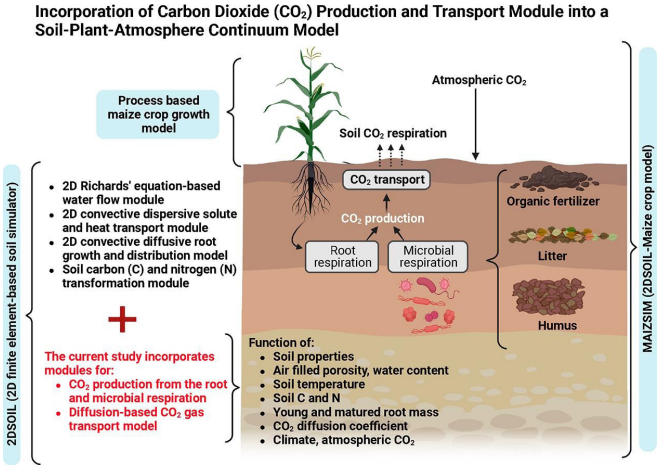
Soil $CO_2$ respiration is a major flux in the global carbon cycle, and the global concern about increasing $CO_2$ levels has driven the need for accurate estimation of soil C storage and $CO_2$ respiration. $CO_2$ release from agricultural soils is influenced by multiple factors, including soil (soil properties, soil-microbial respiration, water content, temperature, soil diffusivity), plant (carbon assimilation, rhizosphere respiration), and atmosphere (climate, atmospheric carbon dioxide). Accurate estimation of the $CO_2$ fluxes in the soil and soil respiration ($CO_2$ flux between soil and atmosphere) requires a process-based modeling approach, considering the complex interactions of all these factors.

Sahila Beegum et al. developed a module for $CO_2$ production via root and microbial respiration and diffusion-based $CO_2$ transport. They integrated it with MAIZSIM (a process-based maize crop growth model that accounts for detailed soil and atmospheric processes). The developed model simulates root respiration based on root mass, root age, soil water content, and temperature. Microbial respiration is based on the soil microbial processes by accounting for the C dynamics in the litter, humus, and organic fertilizer pools as moderated by the soil water content, temperature, microbial synthesis, humification, and decomposition of the carbon pools.

Beegum, Sun, and the team have incorporated this module into other crop models including soybean, cotton, and potato.

"$CO_2$ production and transport module in crop models can help in understanding the impact of different environmental and agricultural management practices on the soil C dynamics and respiration," Beegum said. "The model can also simulate several other climate change and management scenarios. These include the impact of elevated atmospheric $CO_2$ concentration and temperature, different crop varieties, varying carbon-to-nitrogen ratio in the microbial biomass and organic matter pools, etc., on the $CO_2$ soil respiration. These models can be applied to continuous and rotation cropping systems and scaled up for larger spatial analysis."

Beegum said, "Our primary focus is enhancing crop simulation models to capture soil-plant-atmospheric interactions. The crop models with $CO_2$ production and transport module incorporated are now available in the form of a graphical user interface (GUI), which simplifies their usage for farmers and researchers."




Sahila Beegum et al. developed a module for $CO_2$ production via root and microbial respiration and diffusion-based $CO_2$ transport, which is illustrated here.

## Improving Incorporation of Carbon Dioxide Production and Transport Module into a Soil-Plant-Atmosphere Continuum Model

https://doi.org/10.1016/j.geoderma.2023.116586

1. A carbon dioxide production and diffusion-based transport module is developed and incorporated into a process-based soil-plant-atmosphere continuum model called MAIZSIM.
2. The newly developed model can simulate carbon dioxide production from soil organic matter (microbial respiration) and roots (root respiration).
3. Microbial respiration is based on the soil microbial processes by accounting for the carbon dynamics in the organic matter pools as moderated by the soil water content, temperature, microbial synthesis, humification, and decomposition of the carbon pools. Root respiration is simulated based on root mass, age, soil water content, and temperature.
4. The model demonstrates accurate prediction of soil $CO_2$ respiration in response to environmental, soil, and crop growth effects.

**Beegum S, Sun W, Timlin D, Wang Z, Fleisher D, Reddy VR, Ray C. Incorporation of carbon dioxide production and transport module into a Soil-Plant-Atmosphere continuum model. Geoderma. 2023 Sep 1;437:116586.**

# Ebb & Flow

**By Crystal Powers, Research and Extension Communication Specialist**

Crystal Powers

"Knowledge is limited. Imagination encircles the world." ~Albert Einstein

Much of water management and research is planning for the future. However, one of our biggest challenges is getting struck in 'this is how we've always done things.' How can we unleash our imagination to find new opportunities? My imagination has been sparked by several activities going on around campus the past few months. We look forward to adding these activities to our Beyond the Data workshops (stay tuned for more details!)

**Speculative fiction:** At the Water for Food Conference, Elsbeth Magilton, Director of Space, Cyber, and Telecom Law, led a session about how she uses future scenarios in a game format with the Department of Defense, Homeland Security, and others to explore how various actors may behave in dealing with challenges in the emerging areas of space and cyber security. She created a scenario for us based on how an imaginary future terraformed planet, Circe, would deal with a scarce resource. Then we split into small groups, each representing different people including the business community, the government leaders, the concerned citizens, the competing country, etc. and role played: what would we do in this scenario. We then shared to the whole group and responded for a second round. It was great fun, particularly when the government leaders realized the other country was going straight to military options! Overall it was a great opportunity to put ourselves in another's shoes and remove the baggage that comes with discussion of current political options. On this same topic, across campus, several groups are doing a book study on *Emergent Strategy* by Adrienne Maree Brown. She also talks about the many benefits of speculative fiction for helping facilitate discussions of hard topics - if you want to read more about it.

**World Building:** UNL's Johnny Carson Center for Emerging Media Arts students, with Assistant Professor Ash E. Smith, joined the World Building Consortium. With students from five continents, they imagine a world 300 years in the future and explore natural resources, governance, economy, and health. World Building opens the imagination for possibilities of how the world could be. You can find a summary of their program on the UNL website.

As a bit of history buff myself, I often find myself quoting 'nothing new under the sun,' but I love the challenge from science fiction write Octavia Butler adds to that line: "but there are new suns."

## Get water news you can use from University of Nebraska Extension

Are you looking for practical, timely water information you can trust? Then check out the University of Nebraska Extension's water website (**water.unl.edu**). The UNL Water website provides research, information, and educational opportunities about Nebraska's most important natural resource. Five focus areas organize the site: water sources, agriculture production, residential water use, water and climate, and water entities. New articles and events are posted regularly by authors from across the University of Nebraska System. If you'd like to receive these updates in your inbox, you can also sign up for their newsletter (**water.unl.edu/newsletter**).

NWC's Crystal Powers has co-authored two articles this summer on agriculture irrigation: *Don't lose out on Free Nitrogen from Irrigation Water* and *Early Season Irrigation During Drought*. These articles focus on balancing crop needs with nitrogen management in mind to reduce loss to the groundwater.

The Nebraska Water Center contributes regularly to the UNL Water Website. Nebraskans can turn to Nebraska Extension to strengthen their families, inspire their communities, empower young people, conserve and protect natural resources and advance their farms, ranches and businesses. To learn more, visit **extension.unl.edu**.

University of Nebraska

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# Join us at our upcoming event


For more details and to register to attend, visit to **go.unl.edu/waterconference**