Water Resources Center
University of Minnesota

Annual Technical Report
2019

Products

Peer reviewed articles

Chen, Y., R.M. Hozalski, L.G. Olmanson, B.P. Page, J.C. Finlay, P.L. Brezonik, and W.A. Arnold. 2020. Prediction of photochemically produced reactive intermediates in surface waters via satellite remote sensing. Environmental Science & Technology 54: 11, 6671–6681. https://pubs.acs.org/doi/10.1021/acs.est.0c00344

Jia, S. J. Willard, A. Karpatne, J. Read, J. Zwart, M. Steinbach, V, Kumar. (2020). Physics-Guided Machine Learning for Scientific Discovery: An Application in Simulating Lake Temperature Profiles. arXiv preprint arXiv:2001.11086. (in review ACM Transactions on Knowledge Discovery from Data)

Olmanson, L. G., B. P. Page, J. C. Finlay, P. L. Brezonik, M. E. Bauer, C. G. Griffin, and R. M. Hozalski. 2020. Regional measurements and spatial/temporal analysis of CDOM in 10,000+ optically variable Minnesota Lakes using Landsat 8 imagery, Science of the Total Environment 724: 138141. https://doi.org/10.1016/j.scitotenv.2020.138141.

Page, B. P., L. G. Olmanson, and D. R. Mishra. 2019. A harmonized image processing workflow using Sentinel-2/MSI and Landsat-8/OLI for mapping water clarity in optically variable lake systems. Remote Sensing of Environment, 231: 111284. https://doi.org/10.1016/j.rse.2019.111284. [5]

Willard, J. J. Read, A. Appling, S. Oliver, X. Jia, V. Kumar (2020). Predicting Water Temperature Dynamics of Unmonitored Lakes with Meta Transfer Learning arXiv preprint arXiv:2011.05369. (in review Water Resources Research)

Reports

Ishii, S. 2020. Temporal Dynamics Of Pathogens And Antibiotic Resistance In Raw And Treated Stormwater. Report prepared for Minnesota Stormwater Research Council. Available at: https://www.wrc.umn.edu/temporal-dynamics-pathogens-and-antibiotic-resistance-raw-and-treated-stormwater

Data releases

Willard, J., Read, J.S., Appling, A.P., and Oliver, S.K., 2020, Data release: Predicting Water Temperature Dynamics of Unmonitored Lakes with Meta Transfer Learning: U.S. Geological Survey data release, https://doi.org/10.5066/P9I00WFR.

Project-related Presentations Given

M. Kenney, et al. “The Usability Gap In Water Resources Open Data And Actionable Science Initiatives.” INFORMS Annual Meeting, November 2020.

M. Kenney, et al.. “Improving data visualization understandability through user testing.” Ecological Society of America Meeting, August 2020.

M. Kenney, et al. “Simple Ways to Avoid Data Visualization Mistakes.” NOAA CoastWatch Annual Meeting, May 12, 2020.

M. Kenney, et al. “Improving decision support visualization understandability through user testing.” Natural Capital Program Webinar Series, May 5, 2020.

M. Kenney, et al. “Simple Ways to Avoid Data Visualization Mistakes.” Society of Decision Professionals Webinar Series, February, 26, 2020.

M. Kenney, et al. “Predicting Nature to improve environmental management.” U.S. Geological Survey, Powell Center Webinar Series, October 2019.

J. Willard, et al. “Physics-Guided Meta Transfer Learning for Predicting Unmonitored Lake Systems” University of Pittsburgh Seminar on Integrating Scientific Theory with Machine Learning September, 2020.

J. Willard, et al. “Physics-Guided Meta Transfer Learning for Predicting Unmonitored Lake Systems” Workshop on Knowledge Guided Machine Learning (KGML): A Framework for Accelerating Scientific Discovery. August, 2020 .

J. Willard, et al. “Physics-Guided Meta Transfer Learning for Predicting Unmonitored Lake Systems” ESA Annual Meeting - Symposium on Combining Deep Learning and Process-Based Modeling to Advance Ecological Forecasting. August, 2020 .

J. Willard, et al. “Integrating Physical Knowledge into Machine Learning: Applications in Lake Temperature Prediction”, University of Minnesota Water Resources Science Seminar, February, 2020.

J. Willard, et al. ; “Physics-Guided Deep Transfer Learning: An Application in Predicting Lake Temperature”, 2019 CUAHSI Hydroinformatics Conference (Poster), August, 2019.

Information Transfer Program

The WRC’s information transfer activities connect a broad range of stakeholder audiences to the community of water scientists and their latest research findings.

Conferences and Events:

The WRC's signature event is the annual Minnesota Water Resources Conference, which drew a record-breaking audience of 896 participants in October 2019 and 885 participants in October 2020 (virtual format). The WRC also hosted topic-specific events, such as the Climate Adaptation Conference (January 2020, 245 participants), the Conservation Tillage Conference (Dec. 2019, 230 participants), and the Soil Management Summit (virtual Dec. 2020, 200 participants).

Extension:
The WRC houses a team of Extension Educators who develop science-based programming to inform stakeholders on a range of topics including watershed planning, stormwater management, soil health, agricultural fertilizer management, and private well protection. During the reporting period, the Extension team held more than 140 educational events, reaching more than 8,8000 participants.

Online Communications:
The WRC's quarterly Minnegram newsletter reaches a broad statewide audience of over 1,300 subscribers, while our weekly Confluence newsletter reaches 474 subscribers in the academic community. The WRC's Twitter account has 1,688 followers and over 8,300 impressions monthly during the reporting period. The WRC's website, wrc.umn.edu, had nearly 84,000 page views during the June 2018-June 2019 reporting period.

Student Support

- Postdoc (0)
- Graduate (MS, PhD) (2)
- Undergraduate (1)
- NIWR-USGS Student Internship Program (1, PhD)

Notable Achievements and Awards

The Minnesota Department of Agriculture awarded a contract to the **Minnesota Office for Soil Health** (collaboration between the Board of Water and Soil Resources and the University of Minnesota **Water Resources Cente**r) staff to develop a Minnesota Cover Crop Guide. This project expands existing cover crop information by focusing on Minnesota research and summarizing guidance for Minnesota conditions. The guide will explore impacts of cover crop adoption, and management challenges such as selecting cover crop species, establishing and terminating covers, and managing weeds and nutrients in rotations that include cover crops. Approaches to each of these issues vary with the species, soil and landscape characteristics,

and farm operation. The initial web version of the guide is expected in spring of 2020, with new information added as it becomes available.

UMN research on colored dissolved organic matter (CDOM) and remote sensing of water resources is summarized in informational, pocket-sized brochures. The brochures were developed by Patrick Brezonik, Professor Emeritus and former director of the WRC, as part of an NSF grant. Remote sensing researchers and **Water Resources Center** affiliates Brezonik, Ben Page, Leif Olmanson and Jacques Finlay created two videos providing an overview of CDOM research.

Jeffrey Peterson, principal investigator, awarded NSF support to lead water quality priority areas for the Midwest Big Data Innovation Hub.

The UMN **Onsite Sewage Treatment Program** (OSTP) received a second round of funding through a grant from the Minnesota Department of Health to offer educational homeowner septic classes in 2019 and 2020 across Minnesota. Classes cover septic system and well function maintenance. OSTP is housed withing the Water Resources Center.

Melinda Erickson (WRS faculty, SWAC, BBE) attended the 2019 American Geophysical Union Annual Meeting in San Francisco, CA, December 9 - 13, 2019, where she co-chaired a session about geogenic contaminants in drinking water aquifers around the globe. She also presented an invited talk about machine learning models predicting high concentrations of arsenic and manganese in groundwater across the glacial aquifer system, coast-to-coast in the northern US. Additionally, she presented a talk about machine learning models predicting aquifer redox conditions and a poster about general water quality conditions, also in the study area of the US glacial aquifer system.

John Gulliver (WRS faculty, CE) received a 2019 Advisor Award from the Council of Graduate Students, University of Minnesota for excellence in advising. Gulliver also gave the keynote talk Ponds that Release Phosphorus, at the Pennsylvania Stormwater Symposium, Villanova, PA, October 14 – 16, 2019.

Lucy Levers (WRC) was awarded a grant from the Office of Academic Clinical Affairs BOLD Ideas. Lever's project is *Obesity Mapping with state-issued Identification cards.* Lever's collaborators on the project are Ann Zukoski and Jacob Walker-Swaney from the MDH Evaluation and Surveillance Unit, Office of Statewide Health Improvement Initiatives, and Peter Wiringa at U-Spatial.

Water Resources Center Director **Jeffrey Peterson** was elected to serve on the UCOWR Board of Directors for a three year term beginning July 1, 2020. "Being on the board will give me a voice in shaping the future direction of UCOWR and my specific goals are to increase participation from currently underrepresented regions and disciplines while continuing to build UCOWR's partnership with NIWR," said Peterson.

Stephen Polasky (WRS faculty, Applied Economics) was named one of 22 UMN faculty whose research was featured on the 2020 Highly Cited Researchers List by insight and analytics firm

Clarivate Analytics. The international list recognizes researchers who published multiple highly cited papers during the last decade, and whose citation records place them in the top one percent of citation counts for field and publication year according to Clarivate's Web of Science citation index.

Amit Pradhananga and **Mae Davenport** (WRS faculty, Center for Changing Landscapes, Forest Resources) with Emily Green were awarded UCOWR Paper of the Year: *Cultural Narratives on Constraints to Community Engagement in Urban Water Restoration* *Journal of Contemporary Water Research & Education,* Issue 166

Jeff Strock (WRS faculty, SWAC) was awarded the The Soil and Water Conservation Society's Chair's Leadership Award in recognition of exemplary assistance in helping to carry out the goals and objectives of the Soil and Water Conservation Society.

Megan Weber (MAISRC, Extension Educator) was awarded the Universities Council on Water Resources Early Career Award for Extension/Outreach/Engagement, recognizing her contributions and accomplishments in leading development of the Aquatic Invasive Species Detectors Program.

Mojtaba Fakhraee (WRS graduate) was awarded the Universities Council on Water Resources Outstanding Ph.D. Dissertation Award in Natural Science and Engineering.

Brianna M. Loeks-Johnson published findings from her research project, *Upper Midwest lakes are supersaturated with N2* in the July 2020 issue of *Preceedings of the National Academy of Sciences of the United States of America.* The article, co-authored by Loeks-Johnson and her advisor Jim Cotner, chronicles research and findings from their study of nitrogen loss from lakes and the accompanying impact on surrounding watersheds.

University of Minnesota Duluth Water Resources Science student **Kirsten Rhude** was named by Minnesota Sea Grant as their 2020 finalist for the National Sea Grant John A. Knauss Marine Policy Fellowship. Sea Grant's Knauss Fellowship matches nationally selected finalists with host offices of the federal government for a one-year, non-renewable paid fellowship.

Molly Wick, a Water Resources Science Program PhD student at the University of Minnesota Duluth, was selected as the National Estuarine Reserve's first Margaret A. Davidson Fellow. Her funded two-year project will focus on the benefits and well-being people receive following changes in the health of the St. Louis River ecosystem.

Improving The Understandability Of USGS Decision Support Products

Project Type: Coordination Grant
Project ID: 2019MN005S

Project Impact:

The USGS produces three collections of water map decision support products: Water Watch, Water Quality Watch, and Groundwater Watch (the Watches). These are foundational products that are accessed by over 350,000 unique users per year for a range of scientific questions and diverse decision contexts. The three product collections were initiated and sponsored by three different technical offices, and as a result, have evolved independently over several decades. This project undertook a multi-state process to improve the understandability of the Watches. First, we diagnosed the design problems of the current visualizations and found that pages serve many users and use scenarios, but are not designed to do so. Second, we conducted semi-structured interviews to elicit the perceptions of the Watches producers. Amongst the producers there was agreement that modernizing the Watches visualizations will be beneficial, but it needs to maintain the scientific basis and a high-quality experience for technical users. Next, we surveyed the water visualization literature, which emphasized the need to improve guidance on: (i) human factors, (ii) matching visualization to data, task, and context, and (iii) conducting generalizable user studies. Finally, we conducted control vs. treatment testing via public user surveys of the U.S. streamflow map prototypes. Our results indicated that changing the rainbow colormap to brown-blue and prepping respondents with the legend lead to moderate improvements in understandability and efficiency. However, respondents strongly prefer the rainbow colormap and find it more appealing. This work supported evidence-based design modifications to improve the understandability of the Watches.

Machine Learninn to Predict Lake Water Temperature

Project Type: Student Internship
Project ID: G18AC00352

Project Impact:
This project developed new machine learning algorithms for predicting lake temperature dynamics, advancing the state-of-the-art in both the disciplines of computer science and limnology. The use of these models and data spans from informing fisheries management, thermoelectric power production, and related ecological research. Accurate lake temperature predictions from models like those developed in this project can alleviate the high cost involved in manual lake temperature data collection, as well. On the computer science side, lakes are an exemplar application for modeling a situation in which a stark disparity in observations across systems exists. In the lake temperature realm, over 80% of water quality observations come from 20% of observed lakes and many more lakes are completely unobserved. This project cultivated a new perspective on meta transfer learning that uses physical attributes of the systems being modeled, deviating from the traditional statistical and entropy-based properties used for transferring in a meta transfer learning application. In particular, methods for transferring models built from well-observed lakes to similar lakes across the Midwest showed scalability to over two thousand lakes with the promise of eventually going to continental-scale. In the context of the Midwest, the newly developed process-guided meta transfer learning framework outperformed the state-of-the-art for lake temperature process-based models by reducing median root mean squared error across lakes by 29%. Frameworks for both the prediction of lake temperature at various depths and also surface temperature-only models were developed.