Water Resources Center
University of Minnesota

Annual Technical Report
2018

General Information

Products

Jia X, Willard J, Karpatne A, Read J, Zwart J, Steinbach M, Kumar V. Physics guided RNNs for modeling dynamical systems: A case study in simulating lake temperature profiles. In Proceedings of the 2019 SIAM International Conference on Data Mining 2019 May 6 (pp. 558-566). Society for Industrial and Applied Mathematics. https://doi.org/10.1137/1.9781611975673.63

Karpatne, A., Kumar, V., Jia, X., Read, J.S. and Hanson, P.C., 2018, December. Physics guided machine learning: a new paradigm for modeling dynamical systems. In AGU Fall Meeting Abstracts.

Kumar, V., and Read, J.S., 2019 June. Process-guided deep learning: Improving water resource predictions with advanced hybrid models. CUAHSI 2019 Spring Cyberseminar Series: Recent advances in big data machine learning in Hydrology

Kumar, V., Read, J.S., Zwart, J.A., Appling, A.P., Jia, X., Willard, J., Steinbach, M., Hanson, P.C., 2019 July. Physics guided machine learning: A new paradigm for modeling dynamical systems. In CUAHSI Hydroinformatics Conference Abstracts

Olmanson, L. G., Page, B. P., Finlay, J. C., Brezonik, P. L., Griffin, C. G., Hozalski, R. M. and Bauer, M. E. Improved Remote Sensing Approach Toward Automated Regional Measurements of CDOM: a Census of Minnesota's 10,000 Optically Complex Lakes. In Preparation.

Read, J.S., Willard, J., Jia, X., Karpatne, A., Appling, A., Zwart, J.A., Oliver, S., Watkins, W.D., Hansen, G.J. and Kumar, V., 2018, December. Process-Guided Data-Driven modeling of water temperature: Anchoring predictions with thermodynamic constraints in the Big Data era. In AGU Fall Meeting Abstracts.

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Page, B.P., Olmanson, L.G. and Mishra, D.R., 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, p.111284.
ttps://www.sciencedirect.com/science/article/abs/pii/S0034425719303037

Peterson, J.M. "Innovation as a Policy Strategy for Natural Resource Protection." Natural Resource Modeling. Published online June 2019. https://doi.org/ 10.1111/nrm.12231

Willard, J., Jia, X., Karpatne, A., Read, J.S., Zwart, J.A., Appling, A.P., Steinbach, M., Hanson, P.C., and Kumar, V., 2019 July. Physics-guided deep transfer learning: An application in predicting lake temperature. In CUAHSI Hydroinformatics Conference Abstracts

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 850 participants in October 2018. The WRC also hosted topic-specific events, such as the Climate Adaptation Conference (November 2018, 225 participants) and the Minnesota Office for Soil Health Stakeholder Forum (March 2019, 80 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. In 2018, the Extension team held more than 130 educational events, reaching more than 7,000 participants.

Online Communications:
The WRC's quarterly Minnegram newsletter reaches a broad statewide audience of over 1,700 subscribers, while our weekly Confluence newsletter reaches 550 subscribers in the academic community. The WRC's Twitter account has 1,400 followers and over 10,000 impressions each month. The WRC's website, wrc.umn.edu, had over 18,000 unique visitors during the June 2018-June 2019 reporting period.

Student Support

Postdoc
1 - Nicole Hayes

Graduate - PhD
3 - Jared Williard, Seth Thompson, Bri-Loeks Johnson

Undergraduate
2 - Julie Turnbow, Benton Fry

Notable Achievements and Awards

Julia Turnbow ($1700) for "Phosphine detection in Minnesota Lakes"-UROP Award University of Minnesota.

William Arnold (WRS faculty, CE) received the 2018 AEESP Outstanding Publication Award for his PhD dissertation: Pathways and kinetics of chlorinated ethylene and chlorinated acetylene reaction with Fe (0)particles Environmental Science & Technology, 34, (9), 1794-1805, 2000; doi: 10.1021/es990884q). The award was presented at the AEESP Annual Meet and Greet in New Orleans, LA, October 1, 2018.

Daniel Engstrom (WRS faculty, Earth Sciences) was recognized with a Lifetime Achievement Award by the International Paleolimnology Association (IPA) at a joint conference with the International Association of Limnogeology in Stockholm, Sweden in June of this year.

Karen Gran (WRS faculty, Earth and Environmental Sciences, UMD) Noah Finnegan, Andrea L. Johnson (WRS student), Patrick Belmont, Chad Wittkop, Tammy Rittenour won the Kirk Bryan Award for Research Excellence from the Quaternary Geology & Geomorphology Division of the Geological Society of America for their paper: Landscape evolution, valley excavation, and terrace development following abrupt base-level fall.

Bill Arnold (WRS faculty, CE) and Lynn Roberts received the Association of Environmental Engineering & Science Professors award for outstanding publication. The award is given annually to recognize the author(s) of a "landmark environmental engineering and science paper that has withstood the test of time and significantly influenced the practice of environmental engineering and science."

Three WRS faculty, Mark Edlund, Dan Engstrom (St. Croix Watershed Research Station & Science Museum of Minnesota) and Euan Reavie (NRRI) teamed up with colleagues to receive the 2018 Jim LaBounty Award for Best Paper, presented by the North American Lake Management Society. The award recognizes their study, Historical phosphorus dynamics in Lake of the Woods (USA-Canada) – Does legacy phosphorus still affect the southern basin? as the top paper published in the international journal Lake and Reservoir Management.

Deborah Swackhamer (former WRC Director) was honored for her work pushing back on the current US Environmental Protection Agency (EPA) administration in her support of scientific integrity and its use in decision

making. In May of 2017, prior to testifying before the House of Representatives Science Committee Subcommittee on Environment, she was pressured by the chief of staff of the EPA to alter her testimony. She refused. This disobedient act was recognized by the MIT Media Lab in their second annual Disobedience Award ceremony held in Boston November 30, 2018.

Tracy Fallon, (WRS Graduate Program Coordinator) is the 2019 recipient of the Borealis Exemplary Staff award. Borealis, the CFANS Alumni Society, annually recognizes staff for contributions to the CFANS commuity, support of students and CFANS staff, and is highly regarded by students, alumni, faculty and staff.

OSTP and the North Central Region Water Network received the UCOWR Education and Public Service award at the UCOWR annual meeting in Snowbird, UT June 11-13, 2019. The award recognizes educational institutions, individuals, groups, or agencies that have made significant contributions to increase public awareness of water resources development, use, or management covering any one or a combination of the natural, biological, and social sciences.

Bri Loeks-Johnson (WRS PhD student) received the Moos Graduate Research Fellowship for her research on denitrification and nutrient limitation in lakes across a land-use gradient.
Kaitlin Reinl (WRS PhD student) received the 2018 David M. Dolan Scholarship from the International Association of Great Lakes Research, based on her proposal, Assessing future risk of cyanobacteria blooms in western Lake Superior. The scholarship is awarded to a graduate student conducting research using applied environmental statistics or modelling to study the Great Lakes.

Amber White (WRS MS student) was named a 2018 National Science Foundation's Research Fellow. The NSF Graduate Research Fellowship Program recognizes and supports outstanding graduate students in NSF-supported science, technology, engineering, and mathematics disciplines who are pursuing research-based Master's and doctoral degrees.

Incoming WRS MS students Emily Fleissner and Lara Frankson received the Butler and Jessen Fellowships for fall 2018. The Butler and Jessen Water Resources Science Fellowship supports students admitted into graduate programs within the University of Minnesota's Water Resources Center, a leader in freshwater management that connects University of Minnesota expertise to research problems on the national level.

Jeffrey Peterson (WRC Director) delivered the keynote address at the World Conference on Natural Resource Modeling in Guangzhou, China in June 2019.

Projects

A comprehensive, social science-based framework for water resource planning and management in Minnesota

Project Type: Annual Base Grant **Project ID:** 2018MN395B

Project Impact: This aim of this project was to synthesize ongoing research investigating conservation decision-making in rural, urban, and mixed-use watersheds across Minnesota. The specific objectives are to establish reliable indicators of clean water conservation behavior using existing social science data and provide planners and water resource managers with a standardized survey implementation framework and template for statewide assessment and monitoring. Survey samples include landowners, farmers, and residents in twelve study watersheds with response rates ranging from 21% to 46%. The surveys assessed values, beliefs, norms, perceptions about conservation behaviors, and current and future conservation behaviors. In addition, basic sociodemographic information and property characteristics were also gathered. This work will identify and document social indicators of water resource protection and restoration that have been piloted and tested in multiple watersheds. Existing survey data were synthesized using ArcGIS Pro to create geospatially referenced data visualizations and findings for water resource decision making. Using survey data from study watersheds various graphic strategies were tested within GIS to find the best representation of the data while still protecting survey respondent privacy. Each graphic model provides visual results of one dataset or survey question with consideration to the possible range of values. The indicators and measures identified through this analysis can be used to develop a standardized framework and survey template for use in watersheds across the state. Impacts include rapid assessment of key social and institutional variables that influence water-related conservation decision-making.

Advancing remote sensing methods for lake water quality and ice phenology

Project Type: Annual Base Grant **Project ID:** 2018MN393B

Project Impact: Effective lake management requires long-term information on a broad distribution of lakes to enable managers to understand their complexity and changes over time. Although Minnesota has a well-regarded water monitoring program, they assess only a small fraction of its 12,000 lakes and large rivers. Satellite-derived water clarity, which has been measured on thousands of lakes, is included in water quality reports, but full assessments cannot be based on clarity alone; other data are required to determine causes of low clarity. Advances in water data products from remote sensing have excellent potential to improve the reporting abilities of state agencies and assist day-to-day management. We investigated optical and radar based satellite systems to retrieve water quality parameters and ice phenology patterns, respectively, in Google's Earth Engine (GEE), a cloud repository platform for NASA and ESA satellite data that can be accessed via a JavaScript application program interface. The project goal was to develop and validate these automated approaches using GEE using large databases of in-situ data so that alternative methods for lake water quality monitoring and ice phenology can be conducted on a routine basis. Impacts of this project include advancing regional water quality and fish habitat assessments by developing and improving methods to use the Landsat-8 and Sentinel-1/2 satellite imagery to measure water quality and ice phenology indicators of 12,000 lakes at high frequency and low cost.

Assessing the Role of Buffer Strips in Nutrient and Organic Matter Export and Mitigation of Harmful Algal Blooms

Project Type: Annual Base Grant **Project ID:** 2017MN388B

Project Impact: Export of nutrients and organic matter from terrestrial to aquatic systems have led to detrimental effects on aquatic ecosystem function. In Minnesota, buffer strips have been adopted to improve water quality by limiting the amount of nutrients exported from the landscape into aquatic systems. There is growing interest in understanding both the quantity of organic matter that is exported from terrestrial to aquatic systems and how rapidly it is consumed by microbes and converted into inorganic nutrients which can be subsequently taken up by plants. In freshwater systems, the primary consumers of these inorganic nutrients tend to be phytoplankton, which can lead to excessive algal growth and harmful algal blooms. Our results indicate that the agricultural systems in southeast

Minnesota are exporting relatively high concentrations of organic matter. The lability of the organic matter at the edge of field was also very high, i.e., the dissolved organic carbon (DOC) degraded very quickly, potentially releasing associated nutrients such as nitrogen and phosphorous. The rate at which the organic matter degraded was extremely high, with turnover times of 40-60 days. For comparison, measurements in lakes across Minnesota indicate turnover times of DOC on the order of hundreds to thousands of days. We think that these differences are probably due to the labile nature of organic matter produced in agricultural systems and the relatively short processing time. The impact of this work is an improved understanding of edge of field land use practices influence the export of organic matter from terrestrial to aquatic systems.

Student Internship

Project Type: Student Internship **Project ID:** g18ac00352

Project Impact: The impacts of climate change on lakes are significant and accelerating, and monitoring of lakes has revealed widespread warming at rates as much as twice that of sea surface temperatures. Understanding the responses of lakes to these drivers is critical for species conservation and management decisions. Temperature is an ecological "master factor" that controls growth, survival, and reproduction of fish and can predict fish abundance. Warming water temperatures can increase the occurrence and harmful algal blooms (HABs) and aquatic invasive species, both of which may displace native fish. However, lake temperature data are lacking at the relevant spatial and temporal scales needed for decision-making; managers need this information to develop fisheries management objectives and plans under climate and regulatory uncertainty. Despite a lack of national coordination or synthesis, the broad applicability of temperature data in water research and resource management, combined with the relative ease and low cost of sensing, has led to water temperature being the most widely measured of all aquatic parameters (over 400 unique groups monitor water temperature in lakes and rivers nationally). Assembling and harmonizing this wealth of water temperature observations would provide a valuable resource for water resources modeling and analysis. This work will assist in providing more accurate water temperature forecasts. Impacts of improved accuracy are better informed management of a range of water resource issues including the occurrence of HABs and the movement of aquatic invasive species.