CUAHSI allied for water science

CIROH

Global Resilience Institute
at Northeastern University

Building State-Federal Partnership To Leverage The National Water Model For Flood Preparedness

Case Location: State of Missouri, Missouri Hydrologic Information Center (MoHIC)

June 2024

Funding for this project was provided by the National Oceanic and Atmospheric Administration (NOAA), awarded to the Cooperative Institute for Research on Hydrology (CIROH) through the NOAA Cooperative Agreement with The University of Alabama, NA22N-WS4320003.

Background

In 2019, severe flooding impacted much of the Midwestern United States, particularly along the Missouri and Mississippi Rivers, where a combination of excessive rainfall, rapid snowmelt, and saturated soils led to record-breaking water levels. Some areas remained inundated for nearly 279 days, resulting in over $20 billion in damages. These incidents highlighted the vulnerability of the region's communities and infrastructure to hydrologic disasters, spurring a reassessment of the state's flood management and preparedness strategies. In response, Missouri Governor Mike Parson established the Flood Recovery Advisory Working Group (FRAWG) to help the state recover and place it on a path for a more resilient future. The Missouri Hydrology Information Center (MoHIC) originated as an idea in the FRAWG as a way to address the need to develop hydrologic monitoring and warning systems that could help the state and its communities mitigate future flood impacts.

Use Case Summary

Given the devastation of the 2019 floods and the likelihood of increasing frequency of highly disruptive inundations, MoHIC was chartered to create a comprehensive public-facing, statewide, water information dashboard and alert system that would inform and empower both decision-makers and the general public. This is an ambitious undertaking, even in the age of advanced information technology and AI support. At the same time, the National Oceanic and Atmospheric Administration (NOAA) was beginning its work developing and deploying the National Water Model (NWM), with the goal of providing a quantum leap in nationwide water monitoring and prediction capabilities. With version 3.0 now active, the NWM is steadily moving towards the goal of providing detailed, heavily localized modeling through the upcoming Next Generation framework (NextGen). For communities urgently seeking help with managing their current clear and present flood risk, a years-long timeframe for developing enhanced tools can be discouraging. However, with collaboration, there may be a path for meeting near-term needs. If properly coupled with state and local data, the NWM can offer an unprecedented opportunity for localized customization and enhancement that ensures that the significant federal investment in the development of a highly sophisticated, comprehensive national model benefits from and directly supports the collective expertise of state and local water monitoring professionals, academic researchers, and public stakeholders. Such a partnership has the potential to materially advance the timeline and usefulness of the NWM for Missouri's pressing flood mitigation and resilience needs and offers a path that other states can potentially replicate for their particular needs as well.

Recognizing this potential of the NWM, MoHIC and water experts began in 2023 to integrate the tool into the state's hydrologic infrastructure. They started by evaluating and adapting the National Water Model into its operational framework, actively shaping its evolution for their needs. By taking this initiative in collaboration with NOAA and others,MOHIC is helping to foster the development of a vibrant community of practice around the National Water Model, which is spurring ongoing innovation and knowledge exchange across state, federal, local, and academic stakeholders. Such a community of practice will not only advance the practical application of

hydrologic science, but it will also help embed the National Water Model at the core of Missouri's flood resilience strategy, setting a precedent for leveraging advanced predictive technologies against the kinds of complex water management challenges that many communities across the United States are facing. Missouri is not just adopting a sophisticated prediction and monitoring tool, it is laying the foundation for sustained collaboration and capacity building among a broad coalition of partners, setting an example for how other states can take similar advantage of this innovative resource. This approach advances Missouri's vision for long-term resilience, seeking to harness collective capabilities and insights that transcend traditional management boundaries and foster a holistic, integrated, and adaptive water resource management strategy that supports communities' resilience and vitality.

Case Origins

MoHIC first learned about the National Water Model from a sister state agency that was aware of the work being done on the NWM but did not know much about it. Dr. Jessica Wilson[1], MoHIC's Flood Model project lead, began assembling whatever information she could find about the National Water Model. Through internet research and word of mouth, Dr. Wilson found a number of published manuscripts on the National Water Model, but it quickly became apparent that there was a substantial gap between academic discussions around the National Water Model, conducted by and for hydrologic modelers, and the needs of the practitioners who would be the National Water Model's eventual users. Dr. Wilson, like many community-focused practitioners, has substantial water-related expertise (she holds a doctorate in water resources) but little hydrologic modeling experience. Finding it challenging to navigate the gap in modeling knowledge and jargon, Dr. Wilson familiarized herself with basic hydrologic modeling terminology and concepts by creating a Basic 101 Guide so that she and her colleagues were able to contribute towards conversations about the model's function and potential usefulness for their purposes. Dr. Wilson also found attending conferences directed towards flood resiliency, hydrological modeling, and flood emergency alert systems (1; 2) and an assortment of webinars (1; 2; 3) helpful in growing her knowledge of flood modeling generally and the NWM specifically. As Dr. Wilson dedicated time to reading an array of papers and reports describing the NWM, she found the material, at times, dense with underlying data and model algorithms, making it largely inaccessible to non-academic users who were likely to be interested in the model. Seeking clarity, Dr. Wilson began actively engaging in conversations with experienced partners and stakeholders throughout the state on their perception and knowledge of hydrological modeling and the NWM. Dr. Wilson also sought out the expertise from Missouri National Weather Service Regional Forecasting Centers and NOAA's Office of Water Prediction (OWP) where she gained a direct overview of the NWM and the expected services NOAA is working to provide.

Even with a better understanding of the National Water Model's methods, the MoHIC team was unsure how they might use the information provided by the NWM until Zackary Becker, MoHIC's

1. Dr. Wilson is no longer at MoHIC. For inquiries related to this case please contact Zackary Becker.

Unit Chief, found out that NWM's flood inundation mapping (FIM) services would become available in Missouri starting in 2024. Becker recognized the FIM service as a critical asset for Missouri's flood resilience planning, seeing an opportunity for MoHIC to leverage federal resources effectively, thereby extending the center's capabilities without redundant efforts. Becker tasked Wilson with connecting into the NWM network and learning more about it so they could determine how MoHIC could best collaborate and integrate with the national efforts. Because the MoHIC team consists of just four staff, they knew they had to leverage collaboration for the project to succeed. Becker encouraged the team's persistence, often telling them, "It's like we're playing football -- we need to keep pumping our legs until we get to where we want to go."

As the MoHIC team gradually gained the knowledge needed to work with the NWM, the potential benefit of assembling a robust community of practice around the model became evident, prompting the team to actively seek out connections critical to their ability to use the model for their needs. They began forging partnerships with the model's developers and developed working collaborations with Missouri university experts in state hydrology, water systems, geology and topography – as well as other practitioners from across the nation experienced with the NWM. Federal partners like the U.S. Geological Survey (USGS) and the U.S. Army Corps of Engineers (USACE) helped MoHIC to connect and network across the country, also becoming valuable local partners in the effort.

MoHIC's systematic and regular efforts to find and connect with other practitioners cultivated a community of practice that emphasizes peer support and collaborative learning as indispensable tools for navigating the complexities of hydrologic modeling. Such collaborative state-federal partnering maximizes the NWM's potential to help address Missouri's and other states' water management challenges while also expanding federal agencies' understanding of how national platforms and programs can more effectively support state and local needs. With only nascent internal expertise and little practitioner-focused information available, access to a growing community of NWM practitioners can be an important "force multiplier" for state and local users desiring to apply the NWM to their water resilience issues.

Tool Features and Comparisons

Stakeholders in Missouri have prioritized incorporating the predictive FIM capabilities of the National Water Model into a comprehensive statewide water monitoring and warning dashboard as the first step in their usage of the model. This GIS-based visual tool will allow citizens and local decision-makers to access at-a-glance information ahead of and during major weather events and will display information from a variety of sources that will be refined over time.

As MoHIC awaits the rollout of FIM services in Missouri, they have begun to consider how these visualizations will be presented in the dashboard. Researchers from the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) are supporting this process by helping

project stakeholders in Missouri become familiar with the process of obtaining and using NWM outputs. CUAHSI researchers created "dummy data" to stand in for data drawn from a NWM application processing interface (API), which MoHIC and their collaborators will use to investigate how information from the NWM will behave within their GIS system.

While the creation of this service is a significant technical undertaking, it is only half the challenge. Scientific communication is a crucial component of MoHIC's mission–a priority that its partners at the state, local, and federal levels have underscored as well. Information must not simply be available; it must be accessible, useful, and reliable for citizens and decision makers to embrace it. Output from the NWM has the promise of making flood inundation information much more "accessible" and "actionable" for the "average" resident who may lack deep hydrological understanding. Further, the MoHIC sees promise in the tool's ability to aid state and local decision-makers in more effectively planning for and responding to potential flood events. For a new tool, particularly an evolving tool based on inherently uncertain weather forecasting, establishing, and maintaining trust in the reliability of its information is a substantial challenge. MoHIC and its partners will be working diligently to ensure that users of the dashboard understand where flood information is coming from and how it can best be applied.

During the FRAWG meetings in 2019, the Iowa Flood Center (IFC) gave a presentation on the Iowa Flood Information Service (IFIS), which became the inspiration for MoHIC. IFIS utilizes data from IFC's own stream gauges and soil moisture monitoring incorporated into a flood model, including FIM's for select communities, that is presented in a dashboard format. While Missouri has FIMs for certain locations along the Missouri, Kansas, and Meramec Rivers, FIMS cover only a minority of the state. By October 2025, the National Water Model will extend FIM coverage to the entire state of Missouri, with part of the state receiving coverage starting in 2024. Crucially, by using the National Water Model as a starting point, Missouri benefits from a forward-looking capability that could not be generated from stream flow and stage observations alone. While observation-based simulations remain the most accurate source of real-time flood information, the National Water Model also allows users to view 5-day maximum inundation simulations for areas where potential flooding is predicted. Unlike conventional floodplain maps, which are often outdated and difficult to access, these predictions show where inundation may occur during a forecasted weather event.

Future Development

MoHIC has not approached the National Water Model as a static product but as a dynamic tool to be integrated into the ongoing evolution and refinement of their water prediction and management efforts. Missouri's use of the NWM is now part of a years-long development and deployment process, a process necessarily rooted in dialogue between Missouri stakeholders, academic partners, and the National Water Model's development team. As such, Missouri is building a robust "community of practice" centered on advancing the model's capabilities and

usefulness. Nurturing this community as a platform for shared learning, innovation, and the continuous enhancement of hydrologic prediction capabilities will be a fundamentally important aspect of the NWM's continued evolution.

The MoHIC project team has begun to look several years down the road, envisioning a future in which expertise at the state and local level can supplement the capacity and resources available to a federal agency like NOAA. Through this partnership, granular local knowledge and data can contribute to the fine-tuning of the NWM. The Office of Water Prediction's upcoming NextGen framework creates an avenue for such collaboration. As the NextGen framework is rolled out, the current single nationwide model will gradually be replaced by regionally tailored models which improve the resolution, detail, and local performance of the National Water Prediction Service.

Anticipating technological advancements and methodological shifts, the MoHIC team has proactively laid the groundwork for a collaborative effort which reaches across state lines and levels of government and continues to nurture the local applicability of the NWM. MoHIC has initiated discussions with partners in Missouri to begin scoping the integration of 2D HEC-RAS models into the upcoming NWM flood inundation mapping service, as well as the design of a supplemental stage-only stream gauge network, which would supplement the network of U.S. Geological Survey (USGS) gauges that currently underpin the model and support further advancement of the model's hyper-local usefulness.

MoHIC's future objective is to serve the state with a Flooding and Drought Dashboard that ties together all data streams and products into a one-stop shop for Missouri citizens. The dashboard will incorporate the NWM alongside its stream gauge and soil monitoring networks across the state. Ultimately, the goal is to equip Missourians with the necessary data and tools to be resilient in times of flooding and drought.

Limitations and Constraints

Missouri's vision for future application of the NWM will face some challenges. For example;

1. *Skill and personnel requirements*: The technical complexity of the NWM and anticipated HEC-RAS 2D modeling necessitate on-going collaboration and partnership with experts possessing specialized skillsets, highlighting the need for continuous training and development among state and local personnel and stakeholders.

2. *Funding*: Sustained financial investment is essential for supporting the infrastructural and technological upgrades, collaborative research initiatives, and the operationalization of the NWM and NWPS within Missouri.

3. *Weaknesses of NWM in this use case:* Despite its potential, the NWM's current configuration may

not fully account for the unique hydrologic features of Missouri's landscape, underscoring the importance of localized model adaptation and enhancement.

Addressing these challenges is critical for MoHIC, as the successful implementation of the NWM and the realization of a state-centric water prediction paradigm depends on dedicated expertise, strategic coordination, and the fostering of an inclusive, multidisciplinary community of practice. The path forward involves not just navigating these constraints but also leveraging them as catalysts for innovation, collaboration, and capacity building across the spectrum of water resource management in Missouri.

Lessons for Communities

The National Water Model is a young but powerful tool that presents potential users with an opportunity to help shape the evolution of a new and potentially transformative means for hydrologic prediction and flood resilience planning. This dynamic phase of development invites pioneering users to position themselves as the leaders of an emerging community of practice. The key to successfully ensuring that the NWM will meet the nuanced needs of diverse communities is sustaining a willingness to invest in the efforts needed to make the tool useful for localized purposes.

For MoHIC, the NWM represents a publicly available, open-source solution to the challenge of generating visual flood inundation predictions from forecasted precipitation. By using the tool's publicly available, open-source framework, MoHIC demonstrates how communities can leverage scientific tools to enhance local resilience strategies. However, embarking on this journey is not without its considerations, including the need to manage the challenges of integrating cutting-edge technology into existing systems and the uncertainty surrounding the tool's ongoing development and optimization.

The lessons gleaned from MoHIC's experiences underscore several key considerations for communities:

1. *Collaboration is Key*: The formation of a community of practice around the NWM can amplify its benefits, allowing for shared learning and mutual support among diverse users. This collaborative approach can accelerate problem-solving and innovation, making the journey of adaptation a collective endeavor.

2. *Active Engagement*: Embracing the NWM requires a commitment not just to its use but to actively engaging in its continuous improvement and adaptation. This entails providing feedback, sharing local insights, and participating in collaborative development efforts.

3. *Capacity Building*: To effectively harness the NWM, communities, or states on their behalf, must

invest in building the necessary technical capacity, including training personnel in hydrologic modeling and data analysis.

4. *Risk and Reward:* Early adoption carries inherent risks, including the possibility of encountering unanticipated challenges or limitations in the tool's current capabilities. However, it also offers significant rewards by placing communities at the leading edge of water management innovation, enabling them to tailor the tool to their specific needs and challenges.

Through this approach, MoHIC provides a template for how communities can work with emerging technological tools. By weighing the benefits against the potential challenges and fostering a collaborative, engaged stance, communities can not only contribute to but also shape the evolution of tools like the NWM, turning them into pivotal assets for resilience building and disaster preparedness.

Funding for this project was provided by the National Oceanic and Atmospheric Administration (NOAA), awarded to the Cooperative Institute for Research on Hydrology (CIROH) through the NOAA Cooperative Agreement with The University of Alabama, NA22N-WS4320003.