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CIROH

Global Resilience Institute
at Northeastern University

Evaluating The National Water Model In A Local Context

Case Location: Mecklenburg County, North Carolina

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Background

While the National Water Model (NWM) provides many communities with new and valuable information that informs flood-related emergency planning and response, the informational needs of individual communities are varied. As with any new tool, successful users will evaluate the NWM's utility and performance in a local context before incorporating it into their disaster planning and response workflow.

The Challenge

Mecklenburg County, North Carolina has one of the most highly developed flood warning systems in the nation. Developed incrementally since the 1990s, this system has resulted in an extensive network of stream and rain monitoring gauges and sensors. While this data allowed local leaders to better assess flood risk, predicting the extent of flood inundation still remains a challenge.

The Value

This case study is informed by the experiences of Mecklenburg County, North Carolina, home of Charlotte, where local water management officials evaluated the National Water Model as a tool for supplying advance flood predictions. Local officials found that the NWM complements local water-monitoring data, offering valuable lessons for communities. From major urban areas with capabilities similar to Mecklenburg County to smaller communities who have to work with more limited data, the NWM emerges as a vital, cost-free tool. Highlighting the NWM's importance, this use case extrapolates predictions across all rivers and streams using the NWM's 18-hour short range forecast for broader community applications. Ongoing conversations will ensure effective NWM utilization, set future expectations, and validate challenges associated with developing better flood management solutions.

Partner Community Overview

Mecklenburg County, a major urban population center, began strengthening its flood monitoring infrastructure after a series of destructive floods in the 1990s. In the aftermath of those disasters, local emergency managers hoped to leverage existing USGS stream gauges for direct notifications of flood events. This process resulted in Mecklenburg County deploying a flood warning system, which has evolved over decades through partnerships with the City of Charlotte and state and federal agencies. Beginning in 2018, an initiative supported by the U.S. Department of Homeland Security's Science and Technology Directorate deployed new low-cost sensors with the goal of improving flood monitoring. These rugged sensors provide live data, which can detect and automatically alert users to flooding. The goal of this effort was to provide emergency responders with precise information before, during, and after flood events.

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The climate and geography of Mecklenburg County can make rainfall prediction a challenge. The county lies in the Piedmont region, near the foothills of the Southern Appalachians. Thus, most rainfall occurs within convective systems, which produce slow moving thunderstorms and heavy rainfall. When and where precipitation will occur within a convective system is a major challenge for forecast meteorologists. Due to the scattered nature of convective storms, uncertainty in predicting where water will fall makes it challenging to predict where it will flow on the ground, a challenge that becomes especially pronounced in urban areas.

Case Characteristics and Features

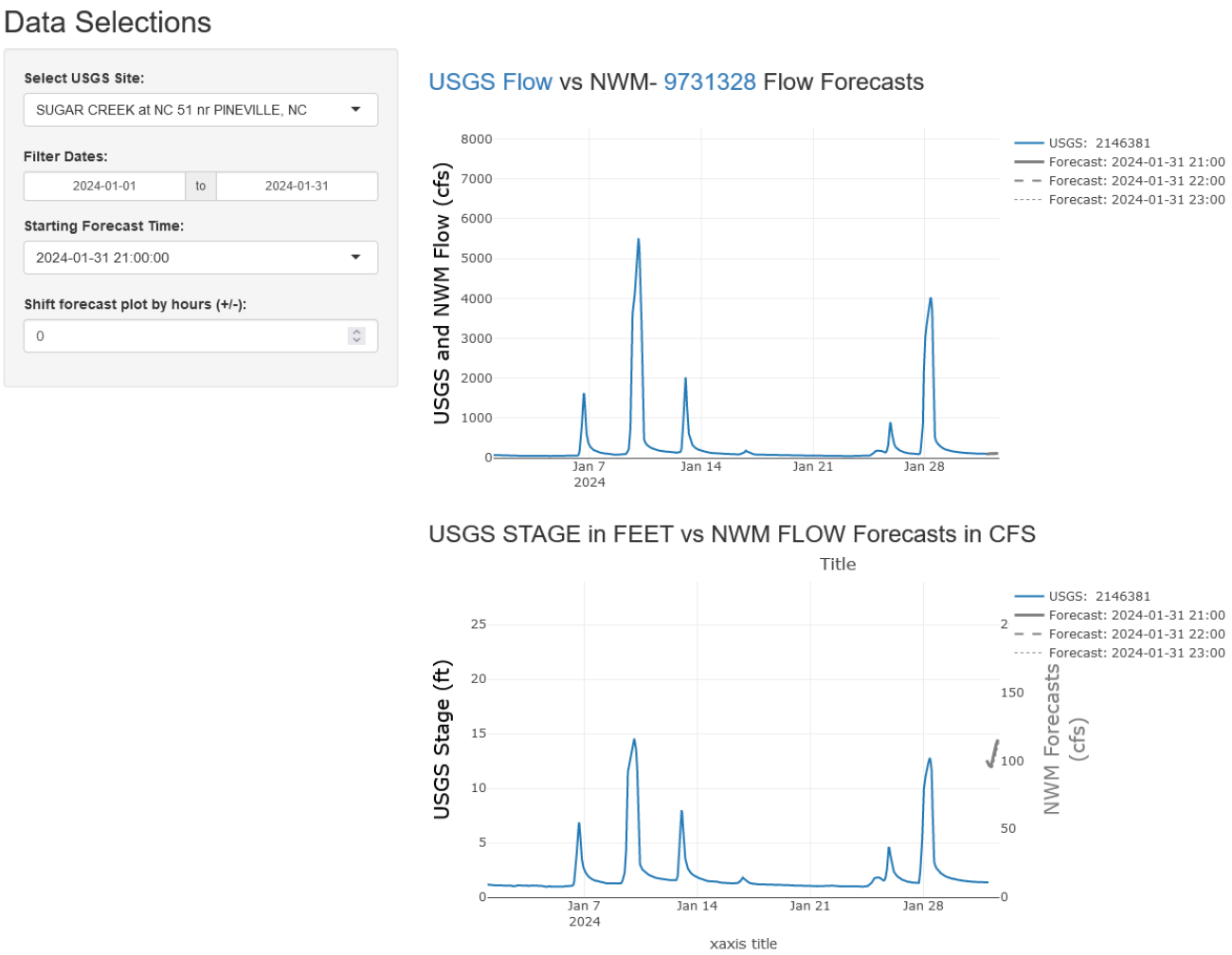
By embracing a proactive approach, emergency managers aimed to prioritize emergency response efforts more effectively ahead of meteorological events. To this end, a sophisticated validation system has been developed, which juxtaposes the NWM forecasts with flow gauge outputs. By developing a validation system which compares NWM predictions against flow gauge outputs, Mecklenburg County's use case explores the efficacy of utilizing the National Water Model in a local context, providing communities broader insights into the strengths and limitations of precipitation-based models in emergency response planning.

From its early stages, the system has evolved to address challenges and incorporate technological advancements to better serve local flood preparedness needs. The need for improved lead time and expanded data resources has become increasingly evident. Before soliciting private vendors, stakeholders in Mecklenburg County considered evaluating the NWM, a public and free-to-use tool offering functions not yet available from private vendors, to be the natural starting point.

While the NWM's online viewer is accessible to any user with an internet connection, communities interested in accessing NWM source data can also integrate NWM data directly into their monitoring and GIS systems. In Mecklenburg County, the project team drew members from county, state, and municipal agencies, and included data scientists, water quality modelers, and engineers well versed in floodplain modeling, mapping, and flood monitoring, as well as a communications

specialist. James Scanlon, a GIS Systems Analyst and floodplain management professional with Mecklenburg County, noted that the Storm Water Planning and Technology they hope to use alongside the NWM, will position them to better predict where flooding will occur, allowing them to issue more detailed and timely warnings. Joel Nipper, a water quality specialist with the City of Charlotte, developed a comparison tool to display NWM flow forecasts alongside actual flow gauge readings from the same time span. At its current state, the tool developed is not fully operational due to issues with data availability and validation, but it shows promise and opens the way for better predictive capability to be developed in the near future as more and better data become available. Moreover, stakeholders hoped that advancement in the usage of machine learning to study relationships between historic rainfall and stream stage might eventually improve the applicability of the NWM for predictive modeling.

Figure 1: Comparison Tool by Joel Nipper: NWM Flow Forecasts vs. Actual Flow Gauge Readings



Successes and Limitations

The National Water Model relies on precipitation forecasts to anticipate when and where precipitation will fall. Thus, uncertainty in weather forecasting, which varies between regions and types of weather systems, is reflected in the NWM's flow predictions. However, local stakeholders, already familiar with the reliability of weather forecasts in their communities, are well-equipped to discern and address potential uncertainties. The region, typically affected by predictable tropical systems, hadn't experienced any during the validation phase, constraining the team's capacity to evaluate the NWM performance in their specific setting. Consequently, as the team aims to analyze the NWM's effectiveness across various storm scenarios, the evaluation is expected to be an ongoing endeavor. Through this iterative process, local stakeholders will strategically decide the optimal timing and methodology for integrating the NWM's predictions into their operational framework as the model continues to advance.

While Mecklenburg County's relatively advanced water monitoring and data analysis capabilities enabled a comprehensive test of the NWM's local performance, stakeholders emphasized that communities without the resources of a major urban area could still benefit from smaller-scale local testing. As forecast uncertainty is often consistent across an entire region, communities without comprehensive water monitoring systems will still likely be able to access regionally relevant data through local, state, or regional agencies, and compare data gathered in real-time to predictions made by the NWM ahead of a storm. However, communities new to the NWM should anticipate the release of the NextGen framework, which will yield improved NWM predictions by fine-tuning the model to account for regional geographic differences. The NextGen framework, an open-source collaboration between the federal government, academia, and field researchers, seeks to advance hydrologic and water resource prediction. This framework will include a common architecture, open-source and standards-based model of development, and user-friendly features to facilitate community-led advancements in hydrologic prediction.

Lessons Learned

The National Water Model is a rapidly developing tool, and feedback from community-led validation efforts like the one underway in Mecklenburg County, NC helps inform future improvements. The implementation of the NextGen framework will further improve the NWM's ability to provide accurate predictions in a diverse range of geographic and climatic conditions. While water planning stakeholders in Mecklenburg County are still in the process of evaluating the local performance of the National Water Model against a well-developed water monitoring system, local water professionals emphasized the value of a free tool that offers significant benefits to communities with limited stream gauge networks, while also providing predictive insights before potential flood events. In communities facing conditions with consistent and predictable precipitation patterns, the National Water Model can help to significantly improve emergency preparedness efforts and bolster the development of more resilient infrastructure.

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