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Global Resilience Institute at Northeastern University

Evaluating The National Water Model As A Data Source For Resilient Transportation Planning

Case Location: Cincinnati Metropolitan Area, OH/KY/IN

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Introduction

The metro-Cincinnati area spans three states and is characterized by its diverse topography and numerous waterways. This region stands to gain significantly from the strategic application of the National Water Model (NWM) as an additional source of data to help visualize and evaluate water-related risks in the vicinity of planned transportation infrastructure projects. This use case was co-developed with stakeholders from the OKI Regional Council of Governments (OKI) that serves as the metropolitan planning organization for the eight-county metro area and develops regional transportation policy and plans to guide allocation of federal transportation funding. By leveraging the NWM, OKI hopes to realize substantial resilience benefits as well as offer a model for other agencies seeking to advance resilient regional transportation planning.

The Challenge

This use case is set against the backdrop of the Greater Cincinnati area that includes communities in the neighboring states of Kentucky and Indiana. The region is marked by diverse landscapes, ranging from urban centers with impervious surfaces contributing to stormwater runoff to rural areas where agriculture predominates and impacts water quality. In short, it is a complex environment for achieving sustainable water management, a challenge exacerbated by climate changes that result in stronger and more frequent storms. Challenges include (1) managing stormwater runoff in densely populated areas; (2) mitigating flood risks in both riverine and flash flood-prone zones, and (3) addressing runoff that affects water quality in downstream water bodies.

Regional planning officials need reliable and adaptable water data to evaluate infrastructure projects for long-term resilience. However, finding this data can be an obstacle to their planning approach, making it challenging to plan for and adapt to a wide range of potential water-based scenarios. Consequently, there is a pressing need for additional options, including a robust, dynamic tool that provides valuable water data, enables real-time analysis, and offers predictive and retrospective insights that are essential for sustainable water resource management and infrastructure planning.

The Value

The interplay between urban development and natural waterways often leads to exacerbated flood risks and pollution issues, necessitating robust and versatile modeling tools like the NWM. This case study is useful for professionals and organizations, such as urban and environmental planners or transportation agencies and engineers, whose work would benefit from additional information about flood risk and impact in a diverse range of locations. By detailing successful strategies for using the NWM, this use case aims to guide regions facing similar cross-jurisdictional water management challenges in adopting more integrated and predictive approaches to environmental planning. Effective application of the insights from this case study depends on collaboration across disciplines and organizations, an effort requiring trust and continuous coordination in order to link jurisdictions, capabilities, and activities. Engagement with local community leaders and policy makers is crucial to ensure that the solutions are practical and grounded in actual community needs and that best practices are coordinated and shared among planners and decision makers.

Beyond the immediate stakeholders, this use case has relevance for a wider audience. Environmental scientists studying the impacts of urbanization on hydrology, civil engineers designing infrastructure resilience in the face of changing water patterns, and urban planners in other metropolitan areas can all derive valuable lessons from this region's experience with the NWM. The case study's findings are particularly pertinent for those in regions where water management must balance urban growth with environmental sustainability.

Partner Community Overview

The Greater Cincinnati area faces complex water management challenges due to its varied topography and extensive urban-rural interface. Because OKI serves communities with diverse characteristics in three states, ranging from a major metropolitan center to rural and agricultural areas, the amount and quality of water data available to planners varies significantly between locations. While the heart of the metropolitan region lies along the Ohio River, numerous other rivers and streams flow through the area as well, most of which are ungauged.

OKI is a regional planning agency that is responsible for the allocation of federal funding, and facilitates local transportation planning for eight counties in three states - Ohio, Kentucky, and Indiana.. OKI assesses proposed projects and allocates funding according to the potential overall impact of the project. Projects impacting areas of greater environmental, social, and economic concern receive more thorough review. OKI participants anticipated that the NWM would provide a valuable additional overlay of water-related information to their existing data, thus enhancing their ability to assess water-related risks in infrastructure planning.

Case Characteristics and Features

The project's first step involved demonstrating the use of observed flow values from USGS stream gauges (where available) alongside retrospective flow estimates generated by the NWM to generate experimental flood extent visualizations for historical events along particular stream segments, employing the Height Above Nearest Drainage (HAND) methodology to estimate inundation extent. Collaborators at CUAHSI developed a Jupyter notebook that provides detailed instructions to guide users through the process of accessing retrospective streamflow estimates for specified stream reaches as well as through the process of generating visualizations from these estimates for any given flow value. Although these estimates are not perfect, and must be used appropriately, the ability to generate inundation maps for specific locations is valuable to planners as a “first pass” filter of potential projects. Such “first pass” estimates can help planners determine where more investigation may be necessary and allow them to quickly identify whether particular locations may be prone to flooding.

Planners also identified a broader utility for this workflow within their site assessment process, as a way to evaluate storm scenarios in locations where a variety of potential water-related concerns have already been identified. By looking through a combination of historical meteorological data, retrospective NWM estimates, and USGS flow observations, planners can calibrate and visualize “design storm” scenarios within a hyper-local context, as small as a single stream segment. While this level of review may not be necessary for each potential project site, such maps can complement existing resources, like FEMA flood maps, by allowing planners to model a range of potential scenarios, not just the most historically exceptional. This proactive and complementary approach of leveraging multiple data sources to water-related hazards allows planners to look beyond high-risk floodplains and frequently outdated maps. Stakeholders noted that pre-generating inundation maps for watersheds in the region would expedite this process, as the maps offer enough resolution to be useful at a variety of scales.

OKI oversees the distribution of federal and state transportation funds for projects in the OKI region but does not conduct design or undertake construction. They do, however, collaborate with constituent communities to ensure that infrastructure resilience concerns are addressed at various stages in the planning process. If this workflow reveals significant flood risk concerns, planners can work with communities to identify and address those concerns both when projects are submitted for long-term consideration, and when they are included in a shorter-term improvement plan. While many sources of data currently available are infrequently updated, the NWM incorporates new information and is fine-tuned on an ongoing basis, allowing planners to consider changes to the built and natural environment throughout the course of an extended planning horizon.

Tool Comparisons and Limitations

Like all models, the NWM has its limitations. As such, users should exercise caution before basing decisions on its predictions. Stakeholders in the Cincinnati area are using the NWM to provide data where data does not exist, and to compare against other data sources that also have their own uncertainties. As part of this use case, collaborators evaluated how the results of the FIM generation process varied based on peak flow estimates from a variety of trusted sources, including FEMA, USGS StreamStats, and the NWM, to better understand how different modeling approaches impacted predictions. For stakeholders, the variation in results underscored the need to consider more than one source. These variations are not consistent across geographies, so users should be careful not to assume that the differences in predictions between sources at one location will necessarily be reflected in all locations.

The NWM is designed to predict fluvial flooding around both gauged and ungauged waterways. It does not address factors such as man-made drainage infrastructure, which makes it an unreliable way of predicting and assessing flash flooding in built-up areas.

The NWM offers value for both highly technical users, and those who are just beginning to engage with water data. Users seeking to simply become familiar with local waterways, access NOAA-generated flood inundation maps (as they are made available), or get current and predicted flow values for local waterways can access information directly through the NWPS viewer. However, accessing data for further analysis requires additional technical skills. Teams aiming for this level of analysis will need, at minimum, a GIS technician who can manage and interpret spatial data, a practitioner skilled in interpreting water data, and some familiarity with Jupyter notebooks and Python.

Lessons for Communities

In this case, stakeholders were surprised and excited by the breadth of data made available by the NWM and believe that the NWM and its related services can serve as an effective complement to other tools and information sources in their planning process. The lessons learned through OKI's experiences point to several key lessons for communities:

1. *Develop Internal Expertise:* Throughout this process, stakeholders from OKI have prioritized learning as much as possible about the NWM. OKI has put a great deal of resources into understanding both the capabilities and limitations of NWM to develop the internal knowledge base needed to apply the Model in a novel use case. As early adopters, they have focused on creating a workflow for the NWM, and, just as crucially, a process that leverages the people best positioned to operationalize that workflow effectively. By convening a small team to serve as the nucleus of NWM knowledge within the organization, including a planning and GIS intern, they ensured that a critical mass of people built the knowledge, skills, and relationships necessary to create organizational momentum around the use of a new tool. Other regional organizations would benefit from a similar approach.

2. *Seek Regional Support*: Not all stakeholders will be able to develop expertise in-house, so this use case process suggests that smaller or less-resources communities seek out local Council's of Government (COG), Metropolitan Planning Organizations (MPO), Regional Planning Commissions (RPC), or other similar entities for assistance in making use of the NWM.

3. *Maximize Available Information:* The NWM is not intended to replace every existing source of water data. Rather, it aims to arm users with information where none currently exists, or provide additional information where some is currently available. All sources of water-related information

have weaknesses and blind spots. By using multiple sources of information alongside each other, users can get a fuller picture of their local water systems, as well as a clearer idea of where uncertainties lie in each individual source.

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