From resilience to adaptation: The case of hurricanes

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A screenshot from an ICoR simulation of a hypothetical Category 5 hurricane in Miami. Flying roof tiles and debris are outlined in red. Credit: University of Michigan

Natural disasters are getting worse. According to data from the National Oceanic and Atmospheric Administration the years 2016, 2017 and 2018 have been historic: in each of those years, the average number of disasters costing at least $1 billion was more than double the long-term average. As the number and cost of disasters continue to increase, communities are looking for ways to adapt and become more resilient.

A resilient community, as defined by the National Academy of Sciences, should be able to prepare and plan for, recover from, and better adapt to actual or potential disasters. Resilience can be assessed in terms of the robustness of a community's physical infrastructure, how its social response is organized, casualty rates and the success of its public policies. These systems are connected, with a disturbance in one propagating through many, affecting overall resilience.

Researchers in the field of disaster science study all of these systems—however, it's a massive field, and specialists are often compartmentalized. University of Michigan Civil and Environmental Engineering researchers, led by Professor Sherif ElTawil, developed the Interdependencies in Community Resilience (ICoR) project to break down the barriers, bring all of this data together, and enable researchers to see the full picture. This is a fundamental step toward building communities that are resilient to disasters.

El-Tawil explained, "Consider a hurricane. The various aspects of a hurricane disaster can be represented by specific models, for example, the wind pressure, building response, people's behavior, etc. All of these models can be made to work in concert with one another to represent the overall disaster scenario. That is what is so unique about this project: it allows for the highest level of integrative research to be done."

To address the complex nature of the problem being addressed, the ICoR project team includes experts in a variety of areas. CEE Professor Vineet R. Kamat and Associate Professor Jason McCormick serve as Deputy Directors, and CEE Associate Professor Carol Menassa and Assistant Professor Seymour Spence serve as Co-Principal Investigators.

The focus of this project is developing a computational platform that researchers from different disciplines can use to plug in their models and work together on a disaster scenario. This project's integrative platform will serve as the link between the research models from diverse fields.

Users will be able to load individual computational models and simulations from multiple disciplines to the platform and run them simultaneously. This will allow for exploration of the complex interactions that take place between different systems before, during and after natural disasters. "This wasn't something we could have done in the past because we just didn't have the computing power," said Spence. "These are very intricate, interdependent calculations that we're now able to explore." The platform can use established models and also allows for the creation of new discipline-specific models, opening the door to scientific discovery that could affect the way we plan against natural disasters like hurricanes.

As Spence explained, "Hurricanes are among the costliest natural hazards to impact the United States, with losses well over $300 billion over the past five years. We wanted to test community recovery in the context of resilience using a novel hurricane recovery model. When we integrated this model through the platform with an existing physics-based vulnerability model, we were able to quantify the resilience of a residential community subject to Category 5 hurricanes. It is this type of information that can ultimately lead to strategies for the long-term adaptation of the community to the hazard."

Data is powerful, but it's not easy to communicate raw numbers. So the research team creates 3-D visual simulations that can run in real-time, using data computed from external software. These help convey the team's findings to the public, making it easier to understand and trust the model. One recent model portrays the effect of strong winds on a neighborhood of houses, as computed by Ph.D. student Ahmed

Abdelhady. "These visuals are very striking," said Abdelhady. "You can see the threatening sky, the rain pouring down, the roof tiles flying off buildings. It really helps you visualize the potential damage to the community and come up with possible solutions to enhance community resilience."

Conveying this information to communities is an important part of the ICoR project. The goal is for communities to be able to use the model to simulate how a disaster would affect them. It can help identify gaps and show how different solutions (for example, the use of hurricane clips to strengthen the connection between the building roof and its wall, one of the weakest points in wooden buildings) could help fill in those gaps.

"The most powerful feature of these models is their ability to predict," said Abdelhady. "You can predict the output of all proposed mitigation plans, then use an optimization algorithm to prioritize them and come up with the best combination." El-Tawil elaborated, "For example, you might see that one solution costs $5 million and would improve community resilience by five percent, but another solution costs $1 million and would improve resilience by 10 percent. With these simulations giving you that kind of data, communities can make informed, responsible decisions about proposed improvements.

Provided by University of Michigan

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