New 'risk triage' platform pinpoints compounding threats to US infrastructure

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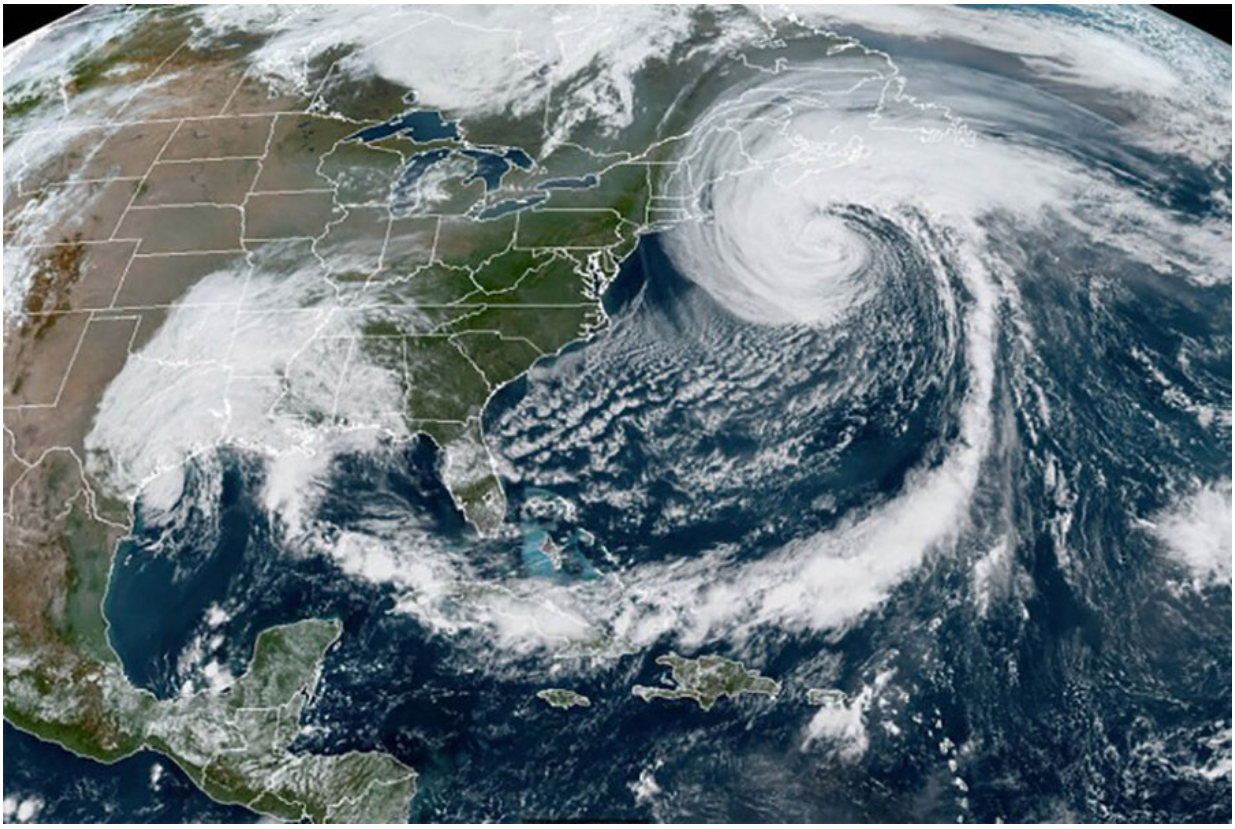

As climate change amplifies the frequency and intensity of hurricanes and other extreme events in the United States and around the world, and the populations and economies they threaten grow and change, there is a critical need to make infrastructure more resilient. A new "risk triage" platform developed by the MIT Joint Program on the Science and Policy of Global Change could help decision-makers to take action to mitigate and adapt to multiple, compounding risks that face the nation. Credit: Severe Weather Europe

Over a 36-hour period in August, Hurricane Henri delivered record rainfall in New York City, where an aging storm-sewer system was not built to handle the deluge, resulting in street flooding. Meanwhile, an ongoing drought in California continued to overburden aquifers and extend statewide water restrictions. As climate change amplifies the frequency and intensity of extreme events in the United States and around the world, and the populations and economies they threaten grow and change, there is a critical need to make infrastructure more resilient. But how can this be done in a timely, cost-effective way?

An emerging discipline called multi-sector dynamics (MSD) offers a promising solution. MSD homes in on compounding risks and potential tipping points across interconnected natural and human systems. Tipping points occur when these systems can no longer sustain multiple, co-evolving stresses, such as extreme events, population growth, land degradation, drinkable water shortages, air pollution, aging infrastructure, and increased human demands. MSD researchers use observations and computer models to identify key precursory indicators of such tipping points, providing decision-makers with critical information that can be applied to mitigate risks and boost resilience in infrastructure and managed resources.

At MIT, the Joint Program on the Science and Policy of Global Change has since 2018 been developing MSD expertise and modeling tools and using them to explore compounding risks and potential tipping points in selected regions of the United States. In a two-hour webinar on Sept. 15, MIT Joint Program researchers presented an overview of the program's MSD research tool set and its applications.

MSD and the risk triage platform

"Multi-sector dynamics explores interactions and interdependencies among human and natural systems, and how these systems may adapt,

interact, and co-evolve in response to short-term shocks and long-term influences and stresses," says MIT Joint Program Deputy Director C. Adam Schlosser, noting that such analysis can reveal and quantify potential risks that would likely evade detection in siloed investigations. "These systems can experience cascading effects or failures after crossing tipping points. The real question is not just where these tipping points are in each system, but how they manifest and interact across all systems."

To address that question, the program's MSD researchers have developed the MIT Socio-Environmental Triage (MST) platform, now publicly available for the first time. Focused on the continental United States, the first version of the platform analyzes present-day risks related to water, land, climate, the economy, energy, demographics, health, and infrastructure, and where these compound to create risk hot spots. It's essentially a screening-level visualization tool that allows users to examine risks, identify hot spots when combining risks, and make decisions about how to deploy more in-depth analysis to solve complex problems at regional and local levels. For example, MST can identify hot spots for combined flood and poverty risks in the lower Mississippi River basin, and thereby alert decision-makers as to where more concentrated flood-control resources are needed.

Successive versions of the platform will incorporate projections based on the MIT Joint Program's Integrated Global System Modeling (IGSM) framework of how different systems and stressors may co-evolve into the future and thereby change the risk landscape. This enhanced capability could help uncover cost-effective pathways for mitigating and adapting to a wide range of environmental and economic risks.

MSD applications

Five webinar presentations explored how MIT Joint Program researchers

are applying the program's risk triage platform and other MSD modeling tools to identify potential tipping points and risks in five key domains: Water quality, land use, economics and energy, health, and infrastructure.

Joint Program Principal Research Scientist Xiang Gao described her efforts to apply a high-resolution U.S. water-quality model to calculate a location-specific, water-quality index over more than 2,000 river basins in the country. By accounting for interactions among climate, agriculture, and socioeconomic systems, various water-quality measures can be obtained ranging from nitrate and phosphate levels to phytoplankton concentrations. This modeling approach advances a unique capability to identify potential water-quality risk hot spots for freshwater resources.

Joint Program Research Scientist Angelo Gurgel discussed his MSD-based analysis of how climate change, population growth, changing diets, crop-yield improvements and other forces that drive land-use change at the global level may ultimately impact how land is used in the United States. Drawing upon national observational data and the IGSM framework, the analysis shows that while current U.S. land-use trends are projected to persist or intensify between now and 2050, there is no evidence of any concerning tipping points arising throughout this period.

MIT Joint Program Research Scientist Jennifer Morris presented several examples of how the risk triage platform can be used to combine existing U.S. datasets and the IGSM framework to assess energy and economic risks at the regional level. For example, by aggregating separate data streams on fossil-fuel employment and poverty, one can target selected counties for clean energy job training programs as the nation moves toward a low-carbon future.

"Our modeling and risk triage frameworks can provide pictures of

current and projected future economic and energy landscapes," says Morris. "They can also highlight interactions among different human, built, and natural systems, including compounding risks that occur in the same location."

MIT Joint Program research affiliate Sebastian Eastham, a research scientist at the MIT Laboratory for Aviation and the Environment, described an MSD approach to the study of air pollution and public health. Linking the IGSM with an atmospheric chemistry model, Eastham ultimately aims to better understand where the greatest health risks are in the United States and how they may compound throughout this century under different policy scenarios. Using the risk triage tool to combine current risk metrics for air quality and poverty in a selected county based on current population and air-quality data, he showed how one can rapidly identify cardiovascular and other air-pollution-induced disease risk hot spots.

Finally, MIT Joint Program research affiliate Alyssa McCluskey, a lecturer at the University of Colorado at Boulder, showed how the risk triage tool can be used to pinpoint potential risks to roadways, waterways, and power distribution lines from flooding, extreme temperatures, population growth, and other stressors. In addition, McCluskey described how transportation and energy infrastructure development and expansion can threaten critical wildlife habitats.

Enabling comprehensive, location-specific analyses of risks and hot spots within and among multiple domains, the Joint Program's MSD modeling tools can be used to inform policymaking and investment from the municipal to the global level.

"MSD takes on the challenge of linking human, natural, and infrastructure systems in order to inform risk analysis and decision-making," says Schlosser. "Through our risk triage platform and other

MSD models, we plan to assess important interactions and tipping points, and to provide foresight that supports action toward a sustainable, resilient, and prosperous world."

More information: The MST platform may be found at est.mit.edu/

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