Hurricane hazards and climate science research in the U.S.

Ning Lin, Associate Professor at Princeton University's Dept. of Civil & Environmental Engineering details her fascinating research on hurricane and climate science by refining methods in risk analysis in this in-depth interview

The experience of Prof Ning Lin from Princeton University is very impressive in terms of her published work and research interests. She is currently leading a multi-year multi-institutional National Science Foundation (NSF) projection on hurricane hazards and risk analysis. She also has an NSF CAREER project on hurricane hazard modelling and application to engineering structure design considering climate change.

In this interview, she reveals her thoughts on research into hurricane and climate science by refining methods in risk analysis. We know that Ning Lin's theoretical risk assessment framework combines physical data with statistics to simulate storms' activity, hazards and risk. This approach projects future hurricane risk and investigates the same from a historical perspective. Prof Ning Lin also describes her research on developing multi-hazard vulnerability models to better predict the damage of hurricane wind and storm surge to residential communities.

Hurricane hazards and risk analysis research

As the interview beings, Prof Ning Lin introduces us to her work on hurricane and climate science by refining methods in risk analysis. Her research group aims to establish a physics-based probabilistic TC risk assessment framework that integrates the analysis of storm activity, hazards, and risk. She explains that they employ a holistic approach to study the impact of climate change on hurricanes, wind, surge and rainfall hazards induced by hurricanes, as well as public policy.

Due to the limitation of historical records and the complexity of the problem, Prof Ning Lin's group apply physics-based statistical methods to their work. This way, large numbers of synthetic but physically possible storms, characterised by their various track, intensity, and size are simulated (with their annual frequencies estimated), under observed or climate-model projected future climate conditions. The hazards induced by the storms are then estimated, to a large extent, with physical models.

Prof Ning Lin observes that this approach has its advantages. One is that while hurricanes often produce multiple hazards such as extreme winds, storm surge and heavy rainfall it is difficult to perform a direct statistical analysis to estimate the joint probability of such events, as the data is very limited, particularly for specific locations. The physics-based approach can generate a large number of physically correlated hazard events for more reliable statistical analysis. The other advantage is that, unlike the direct statistical method, a physics-based approach does not assume that the climate is stationary and so it can be better applied in the context of a changing climate.

Developing multi-hazard vulnerability models

The conversation then moves to her work on refining vulnerability models that describe the damage to coastal communities under the joint forces of strong wind, storm surge, and rainfall flooding. Prof Ning Lin's research into hazards and vulnerabilities is unique because it specifically models the physical correlation of hurricane hazards (strong wind, storm surge and heavy rainfall) and thus their joint impact. In this vein, it can be applied to policymaking, including urban planning and federal and insurance bodies in coastal risk mitigation, because they need to find systematic strategies to be ready for any potential hazards. Prof Ning Lin explains this further and details her research in this area.

"Recent disasters, such as Hurricanes Sandy, Harvey, and Irma underscore the significant vulnerability of the U.S. to hurricanes. We investigated the structural damage caused by these hurricanes and developed vulnerability models, which describe the relationship between damage severity and hazard intensity. Then we can combine, on one hand, the hazard information and on the other, vulnerability information to quantify the risk. Along with my colleagues, we are seeking solutions to predict and prepare for these events.

"In terms of policymaking, the federal government in the U.S. has a policy in place on flooding but there are various issues there that could be improved. Together with Howard Kunreuther of Wharton risk centre at the University of Pennsylvania, we are trying to work with policymakers in the National Flood Insurance Program to better account for the effect of climate change so that the policy as a tool will better support coastal communities.

"We are also working with policymakers in New York City, through the New York City Panel on Climate Change (NPCC), to ensure that they have up-to-date knowledge on hurricane hazards and climate change, so they can use that information to develop policy, for example, in the area of construction.

Work with the National Science Foundation (NSF)

Turning to her work with the NSF, one example of this is Hazard SEES: An Integrated Approach to Risk Assessment and Management in Responding to Land Falling Hurricanes in a Changing Climate. This project is developing a new framework for managing and assessing hurricane risk and will apply to all hurricane-afflicted coastal communities. Here, research is taking place in the coastal communities of New York, New Jersey, North Carolina and Florida to discover and compare hurricane hazards and to estimate how they might evolve in the future. As such, engineering and policy strategies for coping with these hazards can be developed.

While Prof Ning Lin is developing her own model as part of this project, she collaborates with other scientists of varied skill sets, such as Michael Oppenheimer, a Professor of Geosciences and International Affairs at Princeton and Guy Nordenson, an Architecture Professor at Princeton. The scientists involved in this project are developing their own types of models and it brings together various disciplines including atmospheric science, civil engineering, architecture, plus economics and public policy in a holistic way. "In this respect, very good progress is being made because people involved in this project have had to move out of their comfort zone", Prof Ning Lin observes. For example, Guy Nordenson at Princeton leads a 'Structures of Coastal Resilience' study that includes hurricane and climate science into engineering design for coastal resilience, she notes.

Closing thoughts

In closing, we learn that climate change models are surrounded by much uncertainty, so Prof Ning Lin is exploring ways to improve the models and reduce their uncertainties. Such an approach will help us to better understand uncertainties in climate projections and, therefore, improve hazard projections.

In addition, a better design strategy can save much investment and at the same time, ensure that communities remain both safe and alive, as focused by her NSF CAREER project. In closing, Prof Ning Lin shares her views on the importance of design when it comes to tolerating severe weather and also her ambitious plans for the future.

"If you elevate your house, you may get a higher wind impact. If your house is built at a lower level, then you may experience a storm surge impact. Also, storm surge and rainfall flooding can come together as evidenced by Hurricane Harvey, or perhaps not at the same time, but one after the other. A very interesting topic I am addressing is how do we deal with multi-hazards, not only from a scientific modelling perspective but also in terms of a strategy – that is how we could deal with them and consider them together.

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"Our methodology has been applied to a number of different locations, such as New York City, Shanghai and Dubai. We are currently applying our modelling to the entire East Coast and the Gulf Coast of the U.S. This way, we can investigate variations in the hazards and risk from location to location. This is a promising aspect of our on-going work. I would envision that in the future, our study will go beyond the U.S. and encompass a scale that is global in its scope."

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