Hurricane-resistant construction may be undervalued by billions of dollars annually

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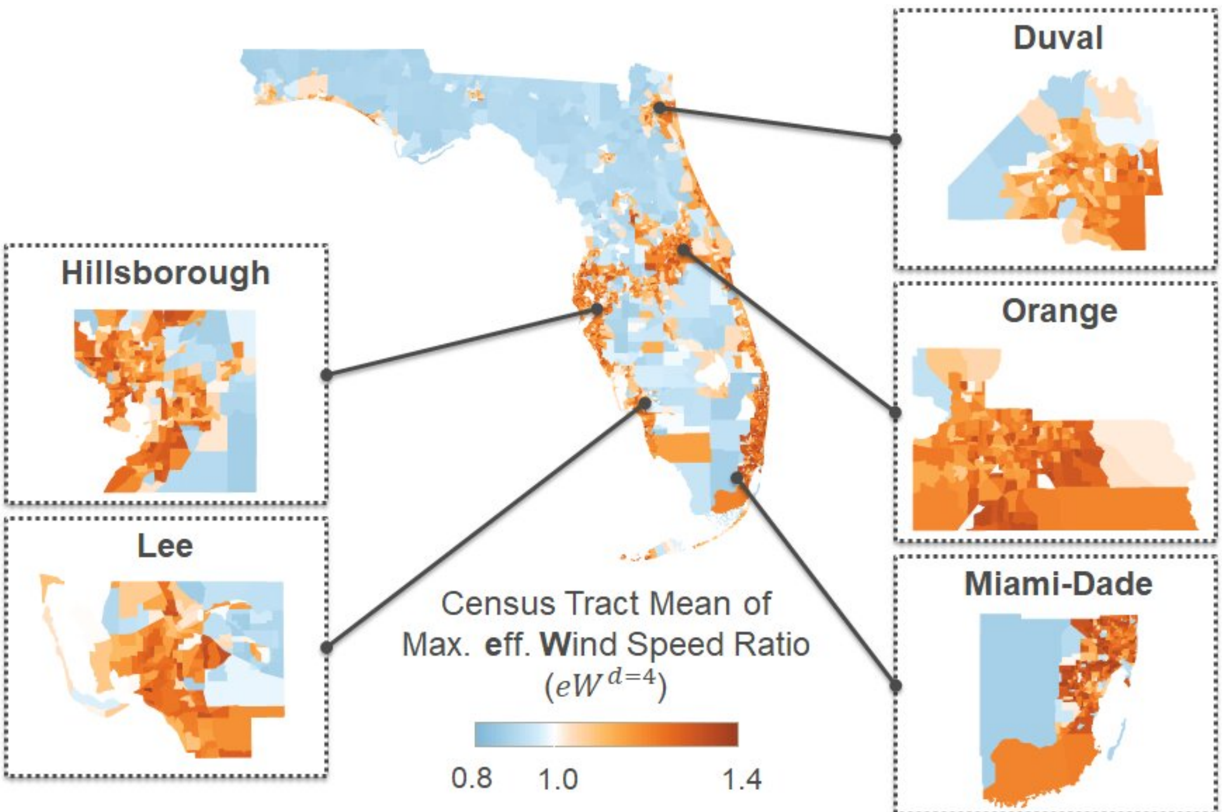

A map of effective wind speed ratio in Florida. Orange coloration indicates census tracts where, on average, structures experience amplifications in wind loads beyond what current tools estimate. Blue coloration indicates census tracts where, on average, structures experience reductions in wind loads. Credit: MIT Concrete Sustainability Hub

In Florida, June typically marks the beginning of hurricane season. Preparation for a storm may appear as otherworldly as it is routine: businesses and homes board up windows and doors, bottled water is quick to sell out, and public buildings cease operations to serve as emergency shelters.

What happens next may be unpredictable. If things take a turn for the worse, myriad homes may be leveled. A 2019 Congressional Budget Office report estimated that hurricane-related wind damage causes $14 billion in losses to the residential sector annually.

However, new research led by Ipek Bensu Manav, an MIT graduate student in civil and environmental engineering and research assistant at MIT's Concrete Sustainability Hub, suggests that the value of mitigating this wind damage through stronger construction methods may be significantly underestimated.

In fact, the failure of wind loss models to account for neighborhood texture—the density and configuration of surrounding buildings with respect to a building of interest—may result in an over 80 percent undervaluation of these methods in Florida.

Methodology

Hazus, a loss estimation tool developed and currently used by the Federal Emergency Management Agency (FEMA), estimates physical and economic damage to buildings due to wind and windborne debris. However, the tool assumes that all buildings in a neighborhood experience the same wind loading.

Manav notes that this assumption disregards the complexity of neighborhood texture. Buildings of different shapes and sizes can be arranged in innumerable ways. This arrangement can amplify or reduce the wind load on buildings within the neighborhood.

Wind load amplifications and reductions result from effects referred to as tunneling and shielding. Densely built-up areas with grid-like layouts are particularly susceptible to wind tunneling effects. You might have experienced these effects yourself walking down a windy street, such as Main Street in Cambridge, Massachusetts, near the MIT campus, only to turn the corner and feel calmer air.

To address this, Manav and her team sought to create a hurricane loss model that accounts for neighborhood texture. By combining GIS files, census tract data, and models of wind recurrence and structural performance, the researchers constructed a high-resolution estimate of expected wind-related structural losses, as well as the benefits of mitigation to reduce those losses.

The model builds on prior research led by Jacob Roxon, a recent CSHub postdoc and co-author of this paper, who developed an empirical relationship that estimates building-specific wind gusts with information about building layout in a given neighborhood.

A challenge the researchers had to overcome was the fact that the building footprints that were available for this estimation have little-to-no information on occupancy and building type.

Manav addressed this by developing a novel statistical model that assigns occupancy and building types to structures based on characteristics of the census tract in which they are located.

Analysis and cost perspective

The researchers then estimated the value of stronger construction in a case study of residential buildings in Florida. This involved modeling the impact of several mitigation measures applied to over 9.3 million housing units spread across 6.9 million buildings.

Texture-related loss implications were found to be higher in census tracts along the coast. This occurs because these areas tend to be more dense and ordered, leading to higher wind load amplifications. Also, these loss implications are particularly high for single-family homes, which are more susceptible to damage and have a higher replacement cost per housing unit.

"Our results sound the alarm that wind loads are more severe than we think," says Manav. "That is not even accounting for climate change, which might make hurricanes more frequent and their wind speeds more intense over time."

The researchers computed expected losses and benefits statewide for hurricane wind damage and its mitigation. They found that $8.1 billion could be saved per year in a scenario where all homes were mitigated with simple measures such as stronger connections between roofs and walls or tighter nail spacing.

Conventional loss estimation models value these same measures as saving only $4.4 billion per year. This means that conventional models are underestimating the value of stronger construction by over 80 percent.

"It is important that the benefits of resilient design be quantified so that financial incentives—whether lending, insurance, or otherwise—can be brought to bear to increase mitigation. Manav's research will move the industry forward toward justifying these benefits," says structural engineer Evan Reis, who is the executive director of the U.S. Resiliency Council.

Further implications

The paper recommends that coastal states enhance their building codes, especially in densely built-up areas, to save dollars and save lives. Manav notes that current building codes do not sufficiently account for texture-induced load amplifications.

"Even a building built to code may not be able to protect you and your family," says Manav. "We need to properly quantify the benefits of mitigating in areas that are exposed to high winds so we promote the right standards of construction where losses can be catastrophic."

A goal of Manav's work is to provide citizens with the information they need before disaster strikes. She has created an online dashboard where you can preview the potential benefits of applying mitigation measures in different communities—perhaps even your own.

"During my research, I kept hitting a wall. I found that it was difficult to use publicly available information to piece together the bigger picture," she comments. "We started developing the dashboard to equip homeowners and stakeholders with accessible and actionable information."

As a next step, Manav is investigating socioeconomic consequences of hurricane wind damage.

"High-resolution analysis, like our case study, allows us to simulate individual household impacts within a geographical context," adds Manav. "With this, we can capture how differing availability of financial resources may influence how communities cope with the aftermath of natural hazards."

More information: Ipek Bensu Manav et al, Texture-Informed

Approach for Hurricane Loss Estimation: How Discounting Neighborhood Texture Leads to Undervaluing Wind Mitigation, *Natural Hazards Review* (2022). DOI: 10.1061/%28ASCE%29NH.1527-6996.0000568

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