Incorporating Neighborhood Texture Into Hurricane Loss Estimation

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Mounting Losses, Novel Methods

According to the National Oceanic and Atmospheric Administration (NOAA), hurricanes and tropical storms have caused nearly $1 trillion in nationwide losses since 1990. As costs mount, stakeholders such as government officials and insurance and reinsurance companies are calling for a greater emphasis on pre-disaster mitigation as opposed to post-disaster response and recovery. However, to create resilient communities, the nation must first improve how it quantifies and communicates hazard risks—in particular, the wind loads and losses created by hurricanes.

Wind loads on a structure derive from the rate of occurrence of storms and the morphologic characteristics of the local neighborhood. These morphologic characteristics are summarized by the terrain, or the density of obstructions such as buildings and vegetation, and the texture, or the detailed configuration of such obstructions. A term

Key Takeaways:

- The CSHub neighborhood texture framework quantifies potential amplifications and reductions in wind-related loads and losses not captured by conventional estimates.
- The greatest amplifications are in neighborhoods of high density and low disorder while the greatest reductions are in neighborhoods of low density and high disorder.
- If the neighborhood texture model informed loss estimation and mitigation planning, Miami-Dade County, Florida could see benefits of $1.69 billion annually.

Miami-Dade County is one of the largest counties in the U.S., with a population of more than 2.7 million. According to the National Risk Index, it's also one of the most vulnerable to hazards, like hurricanes.

coined by CSHub researchers, neighborhood texture introduces a measure of disorder that goes beyond the otherwise conventionally highly regular definition of areal density. **Not considering texture effects results in nearly identical estimates of damage and loss risk levels for buildings within the same neighborhood.** However, previous CSHub research has shown that texture creates local variations in wind loads with some buildings experiencing loads far above conventional estimates and some far below.

In practice, wind load provisions are an essential part of the construction of both building codes and loss estimation tools. Therefore, when these provisions systematically underestimate wind loads, buildings are under-designed and the hazard mitigation of structures is undervalued. The goal, here, is to quantify the margin by which the benefits of mitigating homes is currently underestimated because conventional approaches for assessing these benefits overlook texture effects.

Mapping City Texture

The multi-hazard loss estimation tool, Hazus, developed by the Federal Emergency Management Agency (FEMA), provides a well-recognized framework for assessing the benefits of mitigating. In Hazus, terrain effects are modeled assuming regular spacing among buildings of similar size and height. Such assumptions of regularity are a common thread in field observations and wind tunnel tests that help characterize terrain and its effects—yet they are also simplifications driven by the lack of classical means to quantify disorder.

Previously, CSHub had applied statistical mechanics and computational fluid dynamics to capture disorder and characterize texture and its effects. Expanding on this work, researchers modified local wind speeds from widely accepted wind maps to approximate the impacts of texture and enable the incorporation of these impacts into the Hazus framework.

Here, researchers define a metric of additional benefits (in terms of annualized dollars per household) of mitigating homes when considering texture based on the application of mitigation measures such as shutters, clips, and tie-downs on local residential occupancy types of single-family dwellings, manufactured homes, and multi-unit housing. This metric can be computed for each individual building and is based on the difference between expected benefits with and without the consideration of neighborhood texture where the benefits of mitigating are the difference between expected losses without mitigation versus with mitigation.

Enhanced Loss Estimations

When researchers applied the updated neighborhood texture framework to the hurricane-prone region of Miami-Dade County in South Florida, they found that **hazard mitigation could generate far greater benefits than currently estimated.** To quantify these benefits, researchers first compared wind speed estimations adjusting for local texture with those based on conventional approaches not adjusting for texture (**See Figure 1a**) in census tracts of Miami-Dade County.

Each census tract represents roughly the same number of households. So, denser census tracts are smaller when plotted. These denser census tracts tend to have low disorder and were found to be prone to wind speed amplifications. Less dense, larger census tracts that tend to have higher disorder were found to be prone to wind speed reductions. As a result, **denser census tracts saw greater mitigation benefits** (**See Figure 1b**).

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If neighborhood texture informed mitigation planning, census tracts in **Miami-Dade County would see additional benefits of $671 per year per household**. When tallied up, the entire county would see **additional benefits of $697 million annually,** arriving at net benefits of $1.69 billion annually, for mitigating the residential building stock.

By capturing these additional benefits, the CSHub neighborhood texture model can provide governments, builders and homeowners with more accurate assessments of their hazard risks and incentivize them to invest in hazard mitigation.

In the future, the goal is to expand the scope of this study and create an interactive nationwide map of texture effects. If inequalities in housing, infrastructure and income are considered in loss (and benefit) estimations, our results can aid in planning mitigation efforts, along with managing activities responding to evacuation and potential dislocation.

Figure 1a. Texture effects plotted in terms of census tract means of maximum effective wind speed ratios (the ratio between wind speeds adjusted for local texture and those not adjusted for texture).

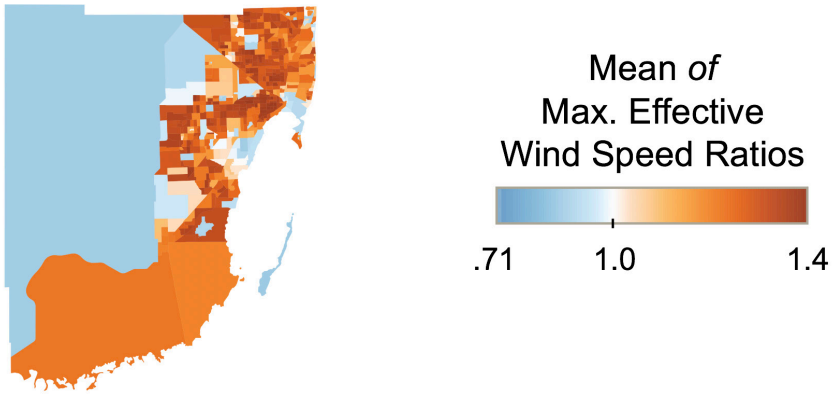
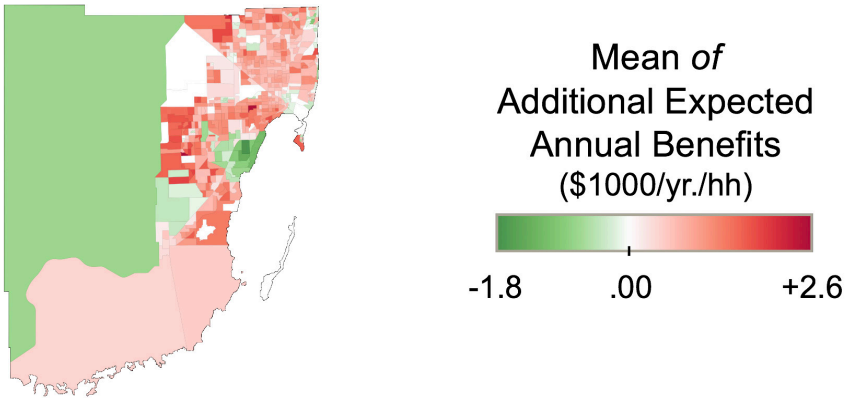


Figure 1b. Texture effects plotted in terms of census tract means of additional benefits of mitigating the residential building stock of Miami-Dade County.



Related Links:

- CSHub Buildings Research
- CSHub Buildings Resilience Research
- CSHub Urban Physics Research

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