9B.8 UPDATES ON THE HURRICANE RISK CALCULATOR: APP CAPABILITIES, RISK MESSAGING, AND PILOT TESTING

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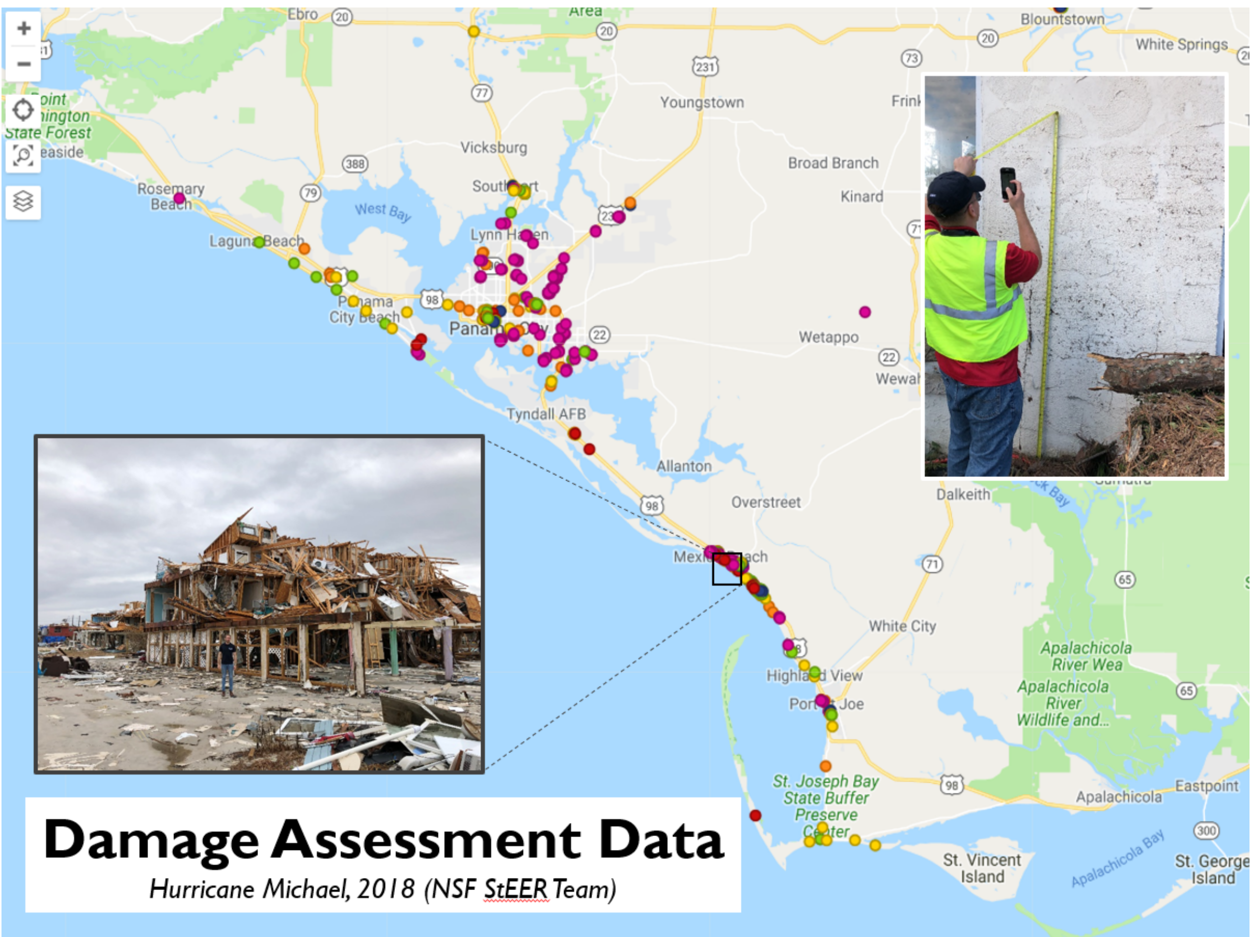

Fig. 1: Summary of structural damage assessment data from the NSF Structural Extreme Events Reconnaissance (StEER) Team following Hurricane Michael. Colors represent different structural damage states.

1. INTRODUCTION

This collaborative research initiative aims to build a state-of-the-art tool to calculate probabilistic hurricane risks for a given location and structure, and to use this information to facilitate risk-informed decisions regarding protective actions. An ultimate goal of the tool is to guide at-risk and lower-risk residents to make more optimal and effective evacuation decisions, thereby lessening strain on the transportation network during hurricane landfall events.

The need, rationale, and approach to such a public probabilistic risk tool has been described previously in Vigh et al. (2018; 2020). Briefly, when a hurricane threatens, people ask questions such as:

- Is it safe to stay in my house?
- When will the winds/floods/surge arrive? How high will they be?
- How much damage will my house experience?
- How long will the power be out?
- When should I put my storm shutters?

Figure 1 shows that structural damage can be very localized, with severe or extreme damage being reported in structures very near to other structures which have light or moderate damage. Thus, the answers to above questions depend critically on each person's location as well as their specific vulnerability. To help users answer such questions about preparation, the Hurricane Risk Calculator intersects real-time probabilistic predictions of hurricane wind hazards from Forecasts of Hurricanes Using Large-Ensemble Outputs [FHLO, Lin et al. 2020; *Copyright Notice and Disclaimer. The data incorporated herein is generated from the use of the Massachusetts Institute of Technology (MIT)'s Forecasts of Hurricanes Using Large-ensemble Outputs (FHLO) version 1.3, © MIT, used with permission. All Rights Reserved.*] with structural vulnerability obtained from the specific structural characteristics of a user's residential structure, obtained from a web-based vulnerability assessment tool called ResilientResidence (ResRe). Further details about the ResRe structural vulnerability assessment are provided in Vigh et al. (2020).

This extended abstract provides updates on three aspects of the project, and is organized as follows. Section 2 details the current and near-term capabilities of the web app. Section 3 describes the format that will be used for risk messaging. Section 4 describes plans for the upcoming pilot test in the U.S. and Australia. Section 5 invites community input and involvement on the project.

2. CAPABILITIES OF THE WEB APP

The Hurricane Risk Calculator is currently implemented as a web application that uses a serverless application model (SAM) to run in Amazon Web Service (AWS). The app includes a data ingest and storage component, an Angular 11 web application, and a REST API. The SAM allows the application to be highly scalable, which should be capable of supporting tens of thousands of simultaneous users. The SAM enables us to skip capacity planning by leveraging AWS provided Platform-as-a-Service components. AWS charges are incurred by actual usage, so resources are not wasted by over provisioning.

The web app handles all functions that would normally be expected of a web app, including sign-up, login, geocoding of addresses, location / profile management, email communications preferences, and the ability to send user feedback to the developers. The sign-in process features a privacy policy and terms of use.

The web app integrates with the ResRe website to assess structural integrity of a user's home. When a user fills out the structural vulnerability assessment at ResRe, their information is sent back to the Hurricane Risk Calculator and stored to facilitate risk of damage calculations. Multiple locations are supported, allowing a user to monitor the risks/hazards for up to 10 locations.

The web app currently provides several location-based services. The first location-based service is a fully zoomable storm map that shows the location of a storm relative to the user's selected location (Fig. 2). Some members of the public are not very geographically-inclined, so such a map helps them understand their location relative to the storm's location. In the future, we plan to enhance this map to overlay fields such as wind speed probabilities or storm surge inundation.

The second location-based service provided by the web app is time-varying probabilistic wind hazard. Figure 3 shows the wind hazard output for a user on Galveston Island from a low-end wind threat. Figure 4 shows the wind hazard output for a major hurricane, demonstrating that FHLO is capable of providing realistic wind hazard outputs for extreme wind events.

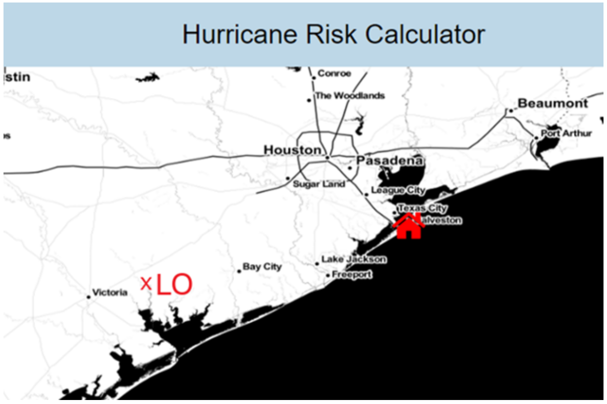

Fig. 2: Example of the interactive mapping capability which displays the user's selected residential location relative to the storm location. The above example shows Tropical Depression Twenty-Two after it had made landfall on the Texas coast.

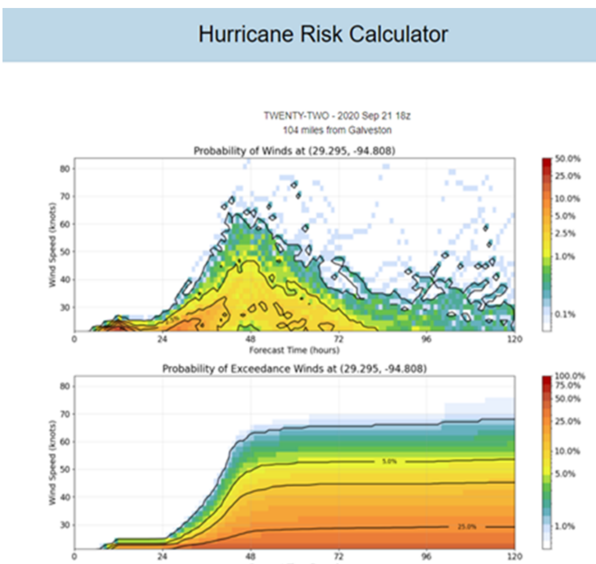

Fig. 3: Example of wind hazard output arising from Tropical Depression Twenty-Two for a user of Galveston Island, based on a FHLO model run from 18Z on 21 September 2020. Upper panel: instantaneous probability density function (PDF) of predicted wind speed. Lower panel: cumulative density function (CDF) of predicted wind speed exceedance.

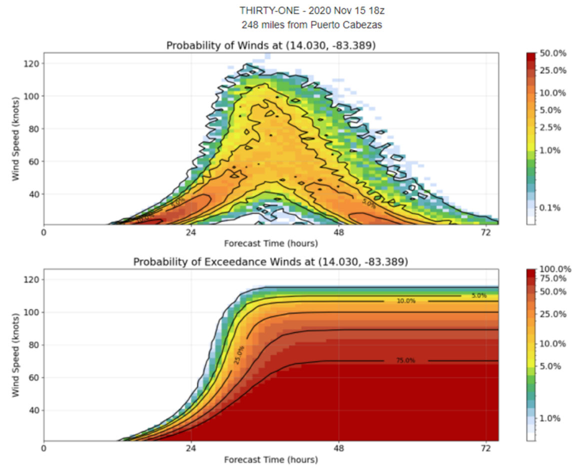

Fig. 4: As in Fig. 3, but for Hurricane Iota for the location of Puerto Cabezas, Nicaragua, based on a FHLO model run from 18Z on 15 November 2020.

3. RISK MESSAGING

The first risk output of the Hurricane Risk Calculator will be the risk of wind damage. This is computed by intersecting the 1000 wind realizations from FHLO against fragility curves specific to the user's residential structure and property. Figure 5 shows illustrative fragility curves for non-structural types of wind damage (wind-borne debris, fences, sheds, and water ingress). Each fragility curve represents the rising probability of damage as wind speed increases.

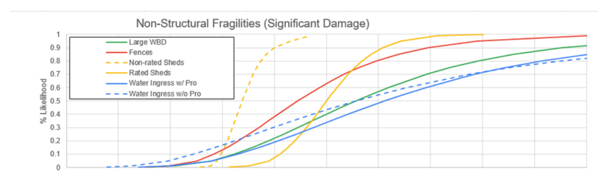

Fig. 5: Example fragility curves for non-structural damage.

In order to simplify the output of what could be dozens of fragility curves specific to each user, the risk of damage will be computed for the relevant components of their building and other non-structural damage (sheds, fences, water ingress). The risk of damage outputs will be combined and reported to the user in a simple color-coded risk communication schema, as shown in figure 6. Because a considerable body of research shows that qualitative descriptions of likelihood are often misunderstood (Wallsten et al. 1986; Reagan et al. 1989; Mosteller and Youtz 1990), we will also provide the actual probabilities for each risk of damage.

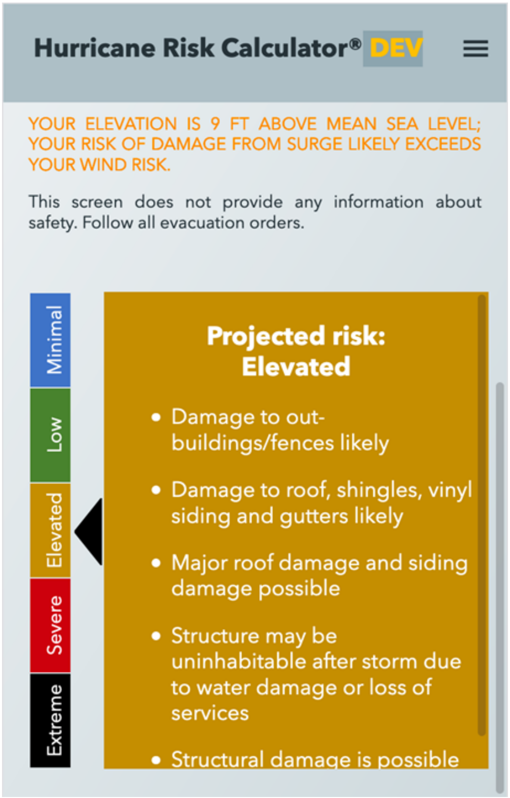

Fig. 6: Example risk of damage output for the 'Elevated' damage level.

Because the current version of the tool focuses on wind risk, we provide disclaimer language which provides the user's elevation above sea level, along with a reminder that their risk of damage from storm surge may exceed their wind risk. Because we are not yet treating all hurricane risks, we emphasize that the risk of damage output does not provide any information about safety. Users are strongly encouraged to follow all evacuation orders.

4. UPCOMING PILOT TEST

Pending completion of the risk of damage output capability, expected sometime in July 2021, we plan to commence a large-scale pilot test of the Hurricane Risk Calculator for the 2021 Northern Hemisphere hurricane season. Our goal is enroll well over 10,000 users across all hurricane-affected coastal states and territories of the U.S. While anyone from these areas will be able to sign-up, the risk of damage outputs will initially only be available to users who live in traditional single-family homes. As the season progresses, we hope to add fragility curves for other types of residential construction, such as manufactured houses. We seek to recruit users from diverse racial, ethnic, and socioeconomic backgrounds. We also plan to provide the tool in Spanish as well as English.

The pilot test seeks to answer a number of questions:

- How accurate are the risk of damage outputs?
- How does the app perform under high-use conditions?
- How much will it cost to provision the web app to each user over the course of a season?

Assuming that the upcoming hurricane season features at least some landfalling hurricanes, the pilot test should provide a wealth of data that will be useful for assessing the accuracy of the tool. We aim to use these data to calibrate the risk of damage outputs against actual damages experienced by all hurricane-affected users. This can be accomplished through comparison with NSF StEER Team damage assessments, as well as by comparing with user-reported damages. We are also undertaking direct verification of the FHLO wind hazard outputs against surface stations.

We aim to demonstrate the app technically under high-use conditions to verify the performance of the serverless architecture model. Such a pilot test with "real-world" users will also enable accurate information to be obtained on the cost of usage. Because of the data-intensive nature of the app, there will always be some cost required to provide the service to users. In the long term, we hope to provide the service to users for free or for a nominal fee ($1.00 per year) in conjunction with one or more commercial partners.

We also plan a pilot for Australia for the upcoming Southern Hemisphere cyclone season for October 2021 through April 2022. This pilot has somewhat different goals. This pilot will seek to enroll several hundred "friendly users" from the disaster response and emergency management communities, including geographically diverse and remote areas. The goals of this pilot will be to obtain feedback from the emergency management communities and demonstrate the web app in the Southern Hemisphere region.

5. COMMUNITY INPUT

In the longer range, we plan to expand the tool to include risk of power outage, risks related to storm surge inundation, as well as to integrate social science into the tool. Eventually we plan for the tool to provide evacuation decision support, leading to more effective outcomes for preparation and mitigation and reduced demand on the transportation system during hurricane landfall events.

To achieve these goals, significant community input will be needed to integrate these new types of information with next-generation forecasting warning and emergency management practices. To this end, a Researcher Collective has been established, spanning the disciplines of social science, human vulnerability, cognitive psychology, emergency management, meteorology, physical and numerical modeling, hazard communication, structural engineering, cloud engineering, and user experience/user design. The researchers in the collective have been organized into teams, as shown in Fig. 7. The collective is open to all researchers and practitioners interested in contributing. We especially welcome participation from the emergency management community, the forecaster community, the storm surge modeling community, the power utility modeling community, and industry. For more information on how to get involved, please see https://wxrisk.ucar.edu or email riskcalculator@ucar.edu.

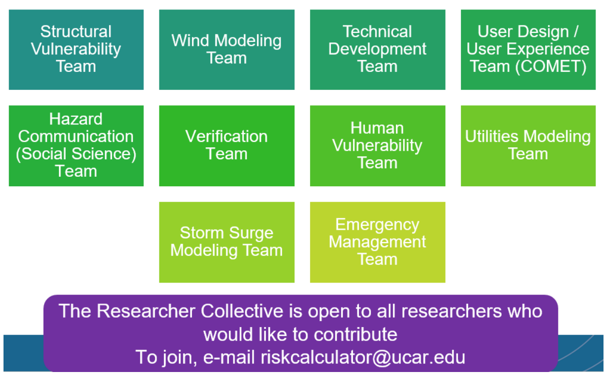

Fig. 7: Graphic showing the organization of the various teams of the Researcher Collective.

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