Scope of Work
"Self-Organizing" Maps for Estimating Wind Speed Triggers for Debris Generation

Proposal to Florida Department of Business and Professional Regulation
Florida Building Commission

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1. Introduction

A wind-borne debris region is an area within hurricane-prone areas where impact protection is required for glazed openings. A multi-step process must be followed to determine if a project is in a Wind-Borne Debris region requiring the protection of openings.

Step 1 – Determine if the project is located in a hurricane prone area.
Step 2 – Determine if the project is located in a wind-borne debris region.
Step 3 – Determine what level of protection is required.

ASCE 7-16 [1] section 26.12 states that glazed openings of a building in hurricane Risk Category II, III, or IV shall be protected if it is :

1. Within 1 mi (1.6 km) of the coastal mean high-water line where the basic wind speed is equal to or greater than 130 mi/h (58 m/s), or
2. In areas where the basic wind speed is equal to or greater than 140 mi/h (63 m/s).

For Risk Category II III or IV buildings located within the wind-borne debris region, the wind speed is determined based on the wind hazards maps provided in ASCE 7-16 [1] section 26.5 (see Figure 1).

We propose to use a "neural network" method to study debris generation and associated debris strikes to protective systems. The results obtained will be compared with the wind hazard maps provided in ASCE 7-16 [1] section 26.5. We will then assess whether the current wind speed triggers for the wind-borne debris region as defined in ASCE 7 are appropriate. The proposed study complements the **Recommendation FL-12a** of the research topics proposed by the FEMA MAT report for Hurricane Michael, which states:

"6) Recommendation FL-12a. Industry groups and/or academia should study debris generation and strikes to protective systems during hurricanes to determine whether the wind speed triggers for the ASCE 7 wind-borne debris region are appropriate.

Industry groups and/or academia should study debris generation and associated debris strikes to protective systems from the 2017 hurricane, as well as for future storms, to determine whether the current wind speed triggers for the wind-borne debris region as defined in ASCE 7 are appropriate. Data collected and analyzed during the study can be used to make recommendations on ASCE 7-required protection of windows and glazed doors.

- *Clear definition of the problem to be researched: What wind speed trigger is appropriate for the ASCE 7 wind-borne debris region for Florida?"*

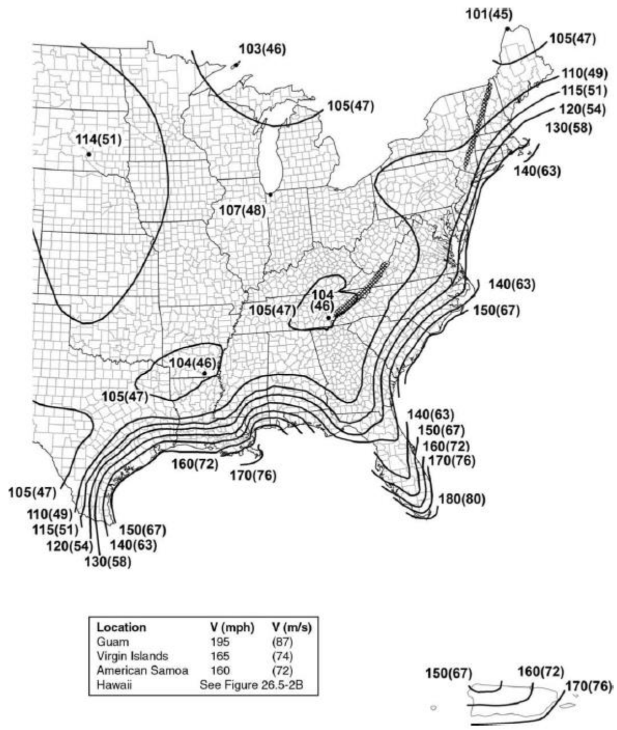

Figure 1: Basic Wind Speeds for Risk Category II Buildings and Other Structures [1].

2. Relevant Sections of the Code

a. Chapter 16 of the Florida Building Code: Structural Design; Section 1609, Wind Loads (Figures 1609.3(1), 1609.3(2), 1609.3(3)).
b. Chapter 26 of the Minimum Design Loads and Associated Criteria for Buildings and Other Structures: Wind Loads: General Requirements; Section 26.2, Definitions; Hurricane-Prone Regions; Wind-borne Debris Regions.
c. Chapter 26 of the Minimum Design Loads and Associated Criteria for Buildings and Other Structures: Wind Loads: General Requirements; Section 26.5, Wind Hazard Map (Figures 26.5-1B, 26.5-1C, 26.5-1D).
d. Chapter 26 of the Minimum Design Loads and Associated Criteria for Buildings and Other Structures: Wind Loads: General Requirements; Section 26.12, Enclosure Classification.

3. Tasks

Task 1

There are several publicly available data sources that could be used for this study. We selected two different data sources:

1. **Regional Navy Coastal Ocean Model (NCOM) [4]:** The regional NCOM has a resolution of 1/30 degree (~3km) resolution in the horizontal and 40 levels in the vertical. The temporal resolution is 3-hours. The regional NCOM ocean prediction system assimilates all quality-controlled observations in the region using the Navy Coupled Ocean Data Assimilation (NCODA) system. Figure 2 shows an example NCOM Regional model output. The dataset available is from March 5, 2013 to present. These include the surface wind stress (N/m^2) and surface roughness (m).

2. **National Data Buoy Center:** There are several stations measuring wind speed along the coasts of Florida. Data availability dates vary from station to station. Most stations include the wind speed (m/s) and wind direction (degrees).

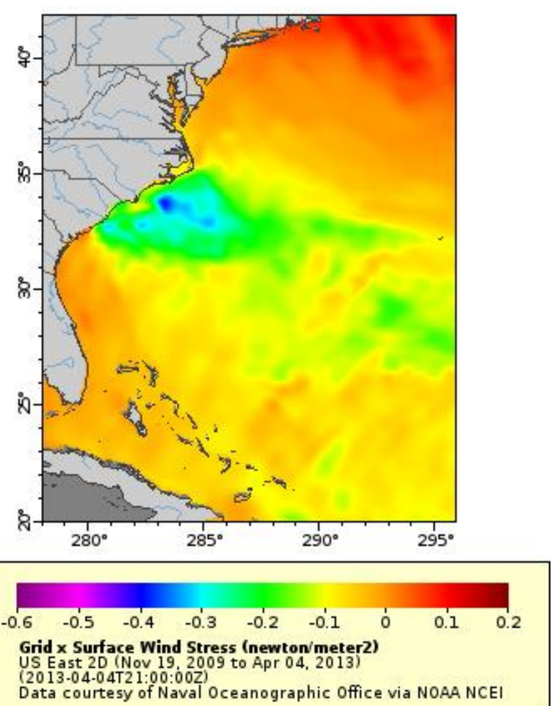

Figure 2: Example NCOM model output.

The datasets acquired will be preprocessed to eliminate the incorrect or missing values. The data will then be pooled together and presented in a unified format for the analysis described below.

Task 2

The "Self-Organizing Map" (SOM) method [2] will be applied to the data sets obtained in Task 2 to generate a wind atlas. The SOM is widely used as a pattern recognition and classification tool for several disciplines, including meteorology [6] and oceanography [3]. The SOM has been shown to be more effective in extracting prevalent features than conventional statistical techniques [3].

The SOM representation of a particular study area is to be created using daily-averaged surface wind stress and wind speed from both datasets.

Task 3

The wind hazard map produced by the SOM method will be cast into different classifications based upon the probability to simplify the interpretation of the results. The resulting map would be quite similar to a typical flood-inundation map, an example of which is shown in Figure 3.

Results obtained in Task 3 will be used to compare the Wind Hazard Maps provided in ASCE 7-16 [1] section 26.5 to evaluate whether the current wind speed triggers for the wind-borne debris region as defined in ASCE 7 are appropriate.

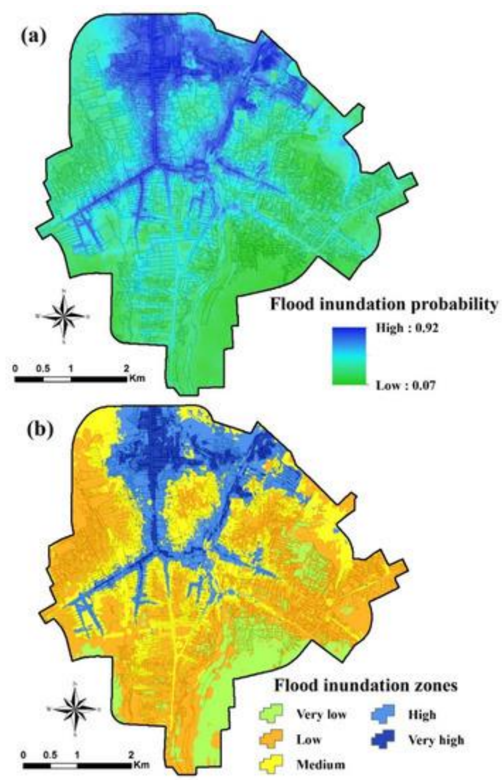

Figure 3: Example of flood inundation potential generated using the self-organizing neural network mapping method (SOMN) model [5].

4. Deliverables

A detailed report will be submitted and will include the following:

a. Data acquisition, storage, organization and preprocessing.
b. Application of the SOM method to the data sets.
c. Comparison of current findings to existing Wind Hazard Maps.

d. Recommendations for future studies.

5. Contract Details

Personnel

PI: Cigdem Akan, University of North Florida, USA
Co-PI: William Dally, University of North Florida, USA
Co-PI: Patrick Kreidl, University of North Florida, USA
Graduate Student: TBD, University of North Florida, USA
Undergraduate Student: TBD, University of North Florida, USA
Undergraduate Student: TBD, University of North Florida, USA
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Method of Payment

A purchase order will be issued to the University of North Florida. This project shall start on the date of execution of the purchase order and end at midnight on June 15, 2022, and shall not exceed $150,000, and will cover all costs for labor, materials, and overhead. Payment will be made for the study after the Contract Manager and the Florida Building Commission's Hurricane Research Advisory Committee have approved the final report.

6. Performance Measures and Financial Consequences

TERI at UNF is solely responsible for the satisfactory performance of the tasks and completion of the deliverables as described in this Scope of Work.

7. Contract Manager

The Contract Manager for this purchase order is Cheresa Boston and the Program Manager is John Kantner.

8. References

[1] ASCE/SEI 7-16 (2017). Minimum Design Loads and Associated Criteria for Buildings and Other Structures, American Society of Civil Engineers, Reston, Virginia, USA.

[2] Kohonen, T. (1982). Self-organized formation of topologically correct feature maps. Biological Cybernetics, 43:59-69.

[3] Liu, Y., and R. H. Weisberg (2005), Patterns of ocean current variability on the West Florida Shelf using the self-organizing map, J. Geophys. Res., 110, C06003, doi:10.1029/2004JC002786.

[4] Martin, P. J. (2000), Description of the Navy Coastal Ocean Model Version 1.0, NRL/FR/732-00-9962, Naval Research Laboratory, Stennis Space Center, Mississippi.

[5] Rahmati, Darabi, Haghighi, Stefanidis, Kornejady, Nalivan, & Bui. (2019). Urban Flood Hazard Modeling Using Self-Organizing Map Neural Network. Water, 11(11), 2370. MDPI AG. Retrieved from http://dx.doi.org/10.3390/w11112370

[6] Reusch, D. B., R. B. Alley, and B. C. Hewitson (2007), North Atlantic climate variability from a self-organizing map perspective, J. Geophys. Res., 112, D02104, doi:10.1029/2006JD007460.