Model for simulating extreme wind speed distribution parameters for hurricane winds

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ABSTRACT:
A model is developed to simulate distributions of extreme wind speeds to be used in structural performance analysis post hurricane landfall. Texas Tech University Hurricane Research Team (TTUHRT) wind data gathered by 15 observations platforms during the landfall of 9 hurricanes is used to compute summary statistics for parent wind fields and extreme value distribution parameters fitting the distributions of extreme winds. Linear relationships and conditional probability tables are computed to use a mean wind speed and one of three roughness regimes to simulate distributions of extreme value distribution location and scale parameters utilizing wind data from 12906 600s wind speed records netting 1591 600s stationary records with mean winds above 15m/s. Conditional tables are presented to facilitate simulation of extreme wind speed distributions for use in scientific and engineering endeavours.

Keywords: TTUHRT, extreme wind distribution, simulation, conditional probabilities

1. METHODS

To facilitate simulating distributions of extreme wind speeds that occur during hurricane landfall wind speed time histories gathered by Texas Tech University Hurricane Research Team (TTUHRT) Wind Engineering Mobile Instrument Tower Experiment (WEMITE) and Portable Mesonet Tower (PMT) platforms, at 10m height, during the 1998 landfall of Hurricane Bonnie, the 2003 landfall of Isabel, the 2004 landfall of Frances, and the 2005 landfalls of Dennis, Katrina and Rita are investigated. Aerial imagery captured close to the landfall of each storm is used to classify the upwind surface roughness regimes in 30-degree directional bins at all TTUHRT platform deployment locations. The TTUHRT wind time histories are broken into 600s windows, checked for stationarity using the Run Test (RunT) and the Reverse Arrangement Test (RAT) (Bendat and Piersol, 1986), and any 600s window with a wind speed below 15m/s is discarded to focus on wind speed records that could lead to significant damage to the built environment. Of the total 12,906 complete 600s windows captured by TTUHRT platforms, 7,915 exhibited no errors during data capture and not well after a storm's landfall. Out of the 7,915 a total of 1,613 recorded a mean wind speed above 15m/s. Out of the 1,613 a total of 22 failed either the RunT or the RAT for stationarity were disqualified leaving a total of 1,591 complete 600s windows across 6 hurricane landfalls. Numerical software is used to compute the location and scale parameters of the distributions of extreme wind speeds mapping the upper tails of the 1,591 600s windows for the raw wind speed time histories, as well as time histories computed by applying a 3s and 60s moving average (MA) to the raw time history. The distributions of location and scale parameters for the raw, 3s MA and 60s MA data are fit using a three parameter General Extreme Value Distribution (GEV). The 1,591 600s windows are then broken into three surface roughness regimes using the aerial imagery assigned surface roughness

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regimes and the wind direction recorded by TTUHRT platforms. The linear relationship between the parent wind field mean wind speeds and the extreme wind field location parameters is quantified and a model for simulating distributions of location and scale parameters is presented using the raw, 3s MA and 60s MA wind data. The model uses the TTUHRT data to quantify GEV parameters for distributions of extreme wind location and scale parameters conditional upon mean wind speed and surface roughness regime. The model is presented in tabular form making the identification of conditional GEV parameters easy for any scientist or engineer needing to simulate extreme wind fields occurring during hurricane landfall.