# Quantification of Wind Speeds in the 19 March 2018 Jacksonville, AL Tornado Through Analyses of Very High-Resolution Tree Damage in a Residential Neighborhood

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## PROJECT GOAL

Use tree damage to provide a detailed set of point wind speed estimates at greater precision than is possible using the tree damage indicators of the enhanced Fujita scale.

## DETAILED DAMAGE SURVEY

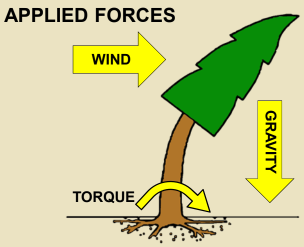
- 19 March 2018 EF3 tornado in Jacksonville, Alabama
- Surveyed a neighborhood just north of the Jacksonville State University campus
- Collected aerial photos via drone and manned aircraft
- Assessed damage to residential structures (FR12), assigning each a degree of damage (DOD) on the EF scale
- Inventoried tree damage, including geographic location, tree species, trunk diameter, height, and type of damage (i.e., intact, uprooted, trunk broken, or partial damage)


Undergraduate students assist with a detailed damage survey in Jacksonville, AL

## MODELING TREE STABILITY

- Determine whether the tree falls at a given hypothetical wind speed
  - A function of species, trunk diameter, height, and crown shape
- Based on an established tree stability model
- As much realism as possible given current knowledge, including estimates of critical turning moments (torque) from tree-winching experiments
- If the wind loading exceeds the estimates of critical turning moment for that tree, the tree falls.
- Can find minimum (maximum) wind speed estimate at the location of each fallen (standing) tree

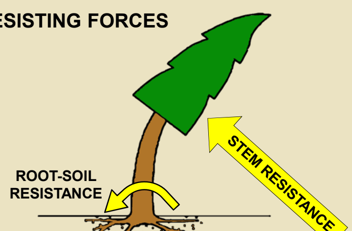
### APPLIED FORCES




**FACTORS**

Wind speed
Crown size
Crown density
Crown mass
Stem mass
Stem elasticity
Tree height
Tip displacement

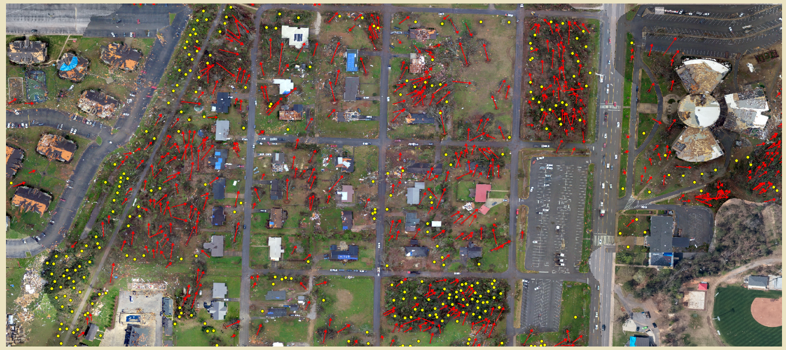
### RESISTING FORCES




**FACTORS**

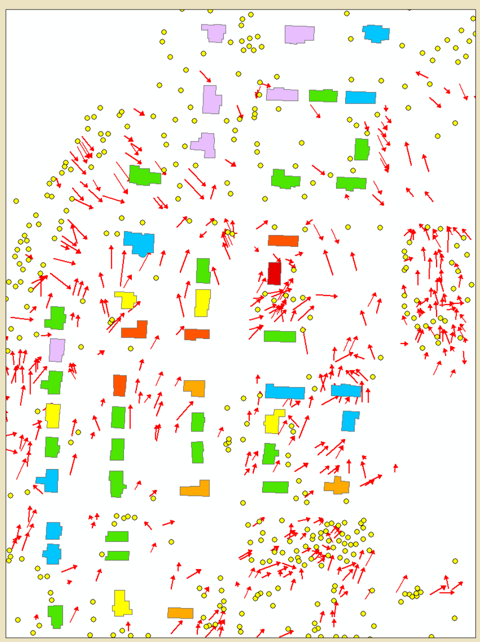
Wood strength
Stem elasticity
Stem thickness
Root-soil weight
Soil shear strength
Root strength

## ESTIMATION OF WIND SPEEDS



Above: Orthomosaic of vertical aerial imagery collected the day after the tornado via a quadcopter drone showing the neighborhood where the detailed survey took place. The high-resolution photos allow geotagging of more than 1600 standing (yellow dots) and fallen (red arrows) trees.

Below: An example of an individual vertical aerial photograph collected by a quadcopter drone the day after the tornado. The drone flew at an altitude of 335 feet.



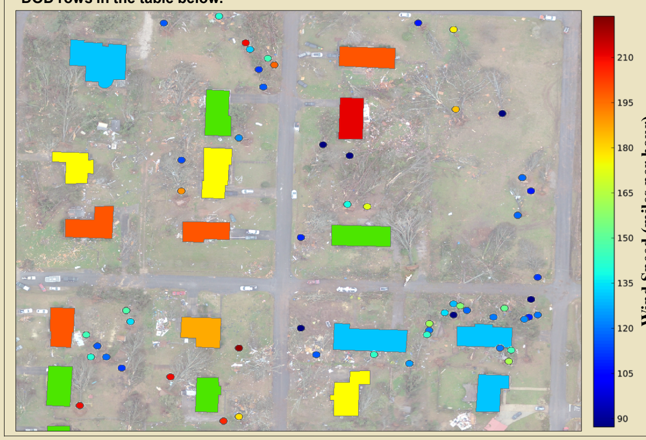
Left: Standing (yellow dots) and fallen (red arrows) trees with footprints of every residential (FR12) structure in the neighborhood, colored by degree of damage (DOD) on the EF scale. Colors correspond with the rows in the table below at right.

Right: EF scale degrees of damage (DODs) for one- and two-family residences (FR12). Expected (EXP), lower bound (LB), and upper bound (UB) wind speeds are in miles per hour. *Note: EF-scale levels are approximate.*

## COMPARISONS BETWEEN WIND SPEED ESTIMATES

Above: Oblique aerial photograph of tornado damage acquired via drone.

Below: Point estimates of the *minimum* wind speed to knock down specific trees (dots, see color bar for values), based on the tree stability model, at the location of a subset of fallen trees subjected to a detailed survey. Structure footprint colors correspond with the DOD rows in the table below.




| | DOD | Damage Description | EXP | LB | UB |
|---|---|---|---|---|---|
| EF0 | 0 | No visible damage | — | — | — |
| | 1 | Threshold of visible damage | 65 | 53 | 80 |
| | 2 | Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding | 79 | 63 | 97 |
| EF1 | 3 | Broken glass in doors and windows | 96 | 79 | 114 |
| | 4 | Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward; failure of porch or carport | 97 | 81 | 116 |
| EF2 | 5 | Entire house shifts off foundation | 121 | 103 | 141 |
| | 6 | Large sections of roof structure removed; most walls remain standing | 122 | 104 | 142 |
| | 7 | Top floor exterior walls collapsed | 132 | 113 | 153 |

## CONCLUSIONS

- These preliminary results depend only on a small subset of the 135 sampled trees.
- This approach to estimating wind speeds is still in an early development stage.
- While the model produced realistic lower-bound wind speeds for most trees, estimates for trees with very large trunk diameters or short heights suffer from model limitations.
- This promising approach provides a point wind speed estimate from trees with more precision than estimates from more traditional EF scale damage indicators.

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