Assisting in Analyzing and Improving the Accuracy of a Mid-Atlantic Hurricane Tree Damage Model

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Mid-Atlantic Hurricanes

• While less frequently than in the tropics, hurricanes hitting the Middle Atlantic States have been recorded as early as the 1680s by early European Settlers

• Primary threats for NJ typically include:
  – Beach Erosion
  – Flooding/Storm Surge
  – Wind Damage

• Depending on the storm, these effects can hold different weight
  – Floyd (1999) and Irene (2011) were primarily flooding events.
  – Sandy (2012), was not a flooding event for most of inland NJ, but rather a wind event.
The HTD Model

Photo by Matt Drews
Hurricane Sandy

- One of the most devastating storms to hit NJ in recent times
  - $30 billion in losses to the state
- 2 million households lost power
  - Inland: Primary cause was treefall taking down power lines
- NJ tree damage was extensive, as most species had not yet dropped their leaves
- Particularly extensive conifer loss statewide
Hurricane Sandy

• As a result of this storm, Richard Birdsey (ret.) and Jason Cole of the US Forest Service teamed up to design and develop a model which would forecast tree damage for incoming tropical systems

• The Hurricane Tree Damage model was born!
Hurricane Tree Damage Model (HTD)

• Simply Stated: The Model forecasts and maps the maximum One-Minute Sustained Wind Speed for the Data
  – Hurricane Sandy was selected as our test case.

• Step 1: Take the forecasted track and wind field diameter data from the HURDAT archive publicly available from the National Hurricane Center and apply it to the HURRECON wind field model devised by Boose et. Al (1994)

• Step 2: Hurricane Track Distance, Bearing, and Velocity are all calculated.
HTD

- Step 3: Radius of Maximum winds (RMW) and B, a parameter which is can alter the shape of the wind profiling curve are both set to specified values (Boose et al 2001 and 2004 give estimations for these parameters)

![Wind Speed vs Radial Distance](image)

**Fig. 2.** HURRECON model. The estimated wind speed along a radial line outward from the storm center is a function of the radius of maximum winds ($R_{ma}$), the wind speed at that radius ($V_{ma}$), and the scaling parameter $B$, which controls the shape of the curve. Each hurricane was modeled using four combinations of $R_{ma}$ and $B$: (a) 20 km, 1.5; (b) 40 km, 1.4; (c) 60 km, 1.3; and (d) 80 km, 1.2. Wind velocity curves are shown for an arbitrary value of $V_{ma} = 50$ m/s.
HTD

- Step 4: Calculate track points for a calculated time step between provided points

- Step 5: Press enter and see the results
The HTD Model

HURDAT Data → Boose et al. HURRECON Model

Model Options (eg grid res.)

Output

More Parameters (future)
Result

- 6 Outputs

(Graphics by Jason Cole, US Forest Service)
Wind Velocity (m/s)  
Gust Velocity (m/s)  

Graphics by Jason Cole, US Forest Service
Next Step

• Now that the wind field was forecasted, validating the winds and applying the field to real world factors would be next

• And so begins my part in this…
My Involvement

• 2015 CRL Summer Fellowship Recipient

• After learning how the model worked from Jason, my involvement was to assist with researching and brainstorming ways to validate the data and parameters that should be included to in order to analyze tree risk.
Part 1: Validating the Wind Fields

- NJ Mesonet data was used and integrated, however the resolution of mesonet stations in NJ was much lower than that of the storm’s resolution.
- It was discovered different papers disagreed with what values of RMW and B are best used in the model. Different values were run through the HTD model, but discerning which one was overall the best was problematic.
- A commercially available product, Hwind, was found to do similar analyses as that of HTD, but was proprietary and financial restrictions prevented in depth analyses between the two.
- Additional Ideas about comparing them to the surface winds estimated by computer models were suggested but not yet explored.
Part 2. Parameterizing the Data for Trees

- Topography
  - Take a topographical map of NJ and analyze the sum of the exposure directions

Graphics By Jason Cole
Part II. Parameterizing the Data for Trees

• Additional Factories that were outlined of varying importance in developing a way to quantify and forecast the tree damage:
  – Storm Surge along the coast
  – Forest Type
  – Soil types and soil moisture
  – Forest Health and density
  – Level of urbanization
  – Time since last major tree fall
  – Season (have leaves fallen from deciduous trees yet?)
One Large Problem Discovered

- There is one crucial data set that to our knowledge does not exist, and that is a large scale inventory of tree fall from post-Hurricane Sandy
  - The only known acre by acre survey of tree damage from Sandy was conducted by Dr. Rick Lathrop (Rutgers CRSSA) and his students for the Rutgers Ecological Preserve in Piscataway, NJ

- This provides great difficulty to validate how accurate our predictions for where the treefall would be the worst in Sandy, as little data exists for determining where it actually was.

- (Perhaps this would be a great area of research for an aspiring forestry student)
Project’s Current Status

• As of Spring 2016, the project has been rested for the moment
  – Richard Birdey’s retirement, coupled with difficulty in advancing the validation of the model’s output.
  – Lack of recorded tree damage data made fitting the wind maps to correlate with the data nearly impossible

  – Any ideas of suggestions are welcomed!
A little on my Primary Research

- Surface-based meteorological instrumentation
- Lower Atmospheric Wind Patterns
- Mesonet data applications
- Surface Energy Budgets
Personal Research Benefits from This Project

• A much better perspective on how important surface measurements are in verifying fledgling models and analyses
• Learning how to incorporate ArcGIS into meteorological modeling
• Realizing the issue with data gaps
• Ways to process wind data for a multitude of uses
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