In-Situ Measurements and Tree-Fall Pattern Subcommittee

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In-Situ Measurements – State of the Science

• Rare for fixed or portable observing stations!!
• Difficult to obtain, or instruments will be damaged by high winds/debris
• Key to understanding near-surface wind characteristics to inform tornado loading
In-Situ Measurements – Available Data

- Some cases have been obtained from fixed and portable platforms [8]
  - Mobile mesonet, POD measurements (Wurman and Kosiba)
  - 100 mb pressure drop from tornado in 2003
  - Fixed platform measurements from Oklahoma Mesonet and West Texas Mesonet
  - Likely others from surface observing stations (e.g., 2010 Arizona tornado – measuring carbon fluxes
6.1 Purpose

6.2 Scope

6.3 Applicability

6.4 Definitions

6.5 Symbols and Notations

6.6 General Requirements

6.7 Wind Speed Estimation Procedure

  6.7.1 Standardization
    • 6.7.1.1 Conversion Between Averaging Times
    • 6.7.1.2 Conversion Between Heights
    • 6.7.1.3 Conversion for Exposure

  6.7.2 Archival

Standard and associated Commentary is SHORT
SCOPE (PARTIAL) – ITEMS FOR ARCHIVAL

In order to meet the minimum requirements for estimation (and possible standardization) the following archival data and associated metadata from these instruments will be required:

1) Maximum wind speed (in mph or m/s) – AND IT’S ASSOCIATED METADATA:
   - Height above ground level (AGL, in feet or meters)
   - Averaging time (in seconds)
   - Estimate of exposure conditions for all wind direction sectors (photographs permitted) – USE OF ASCE 7 EXPOSURE CATEGORIES AND SECTOR ANALYSIS?
   - Instrument model and type (photograph permitted)
   - Sampling rate or frequency
   - Geographic location (latitude, longitude)
   - Time(s) of measurement

Q1: Should we effectively filter out “bad” measurements?  
Q2: How should we do that?
Many references show significant case-by-case variability in profiles, etc…
Although no true standardization is taking place, it is still important to have the associated metadata to get an idea of spatiotemporal properties
UNLESS full time history and multiple levels are available (not required)

“…For wind speed generated by hurricanes and extratropical storms, methods of standardization outlined in ASCE 7-16 will be permitted.”
Tree-Fall Measurements – State of the Science

- Becoming an accessible alternative method to estimating wind speeds
- Many tornadoes do not damage structures (touchdown in rural, forested areas)
- This type of analysis started in the 1920s; however has rapidly accelerated due to computing power and proliferation of aerial photos
Tree-Fall Measurements – Available Data

Joplin, Missouri Tornado 2011

Yellowstone NP Tornado 1989
Tree-Fall Measurements – Available Data

- Idealized tornado model used – Rankine vortex
4.1 Purpose
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  4.7.1 Method 1
  4.7.2 Method 2
  4.7.3 Method 3
C.4.7 Methods
  C.4.7.1 Method 1
  C.4.7.2 Method 2
  C.4.7.3 Method 3
References
Method 1 - Karstens et al. 2013

1. Digitize tree-fall, max damage line.
2. Define a damage path or “Spatial Extent of Damage”
   - Align with ongoing “width” discussion
3. Normalize tree distance to line of max damage.
Section 4. Compute normalized mean cross section of tree-fall.

Section 5. Compare to results from analytical vortex simulations.

Section 6. Approximate mean near-surface wind field.

**Method 1 - Karstens et al. 2013**

Vortex Simulation \( (V_t=43.0, V_r=86.0, V_s=11.0) \)
**Damage Width (DW):** Width of tree fall

**Damage Ratio (DR):** Ratio of tree fall width on either side of “convergence line” (180 deg to $V_T$)

**Tree Fall Direction Distance ($\beta$):** Distance from convergence line where tree fall directions were 90 and 180 degrees.
Method 2 – Lombardo et al. 2015

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**Left:** Estimated wind speed and direction time history for a specific grid-point

**Below:** Estimated maximum wind speed associated with EF-number in Joplin

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Joplin, MO Tornado – NIST
Method 3 – Godfrey & Peterson 2017

1. **Ground-based distribution of tree heights, trunk diameters, species, etc...**
2. **Sample distribution and employ wind-tree resistance model**
3. **Calculate probability of tree-fall for number of wind speeds**
4. **Compare to remote-sensed estimates of tree-fall probability (above)**
5. **Wind speed estimation (most-likely)**
Method 3 – Godfrey & Peterson 2017